Final Report of the California Joint Agencies Vehicle-Grid Integration Working Group

June 30, 2020

California Public Utilities Commission
DRIVE OIR Rulemaking (R.18-12-006)

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Disclaimer: This report does not address every aspect of VGI, but rather provides a starting point for further rulemaking, policy, and programs for VGI by the California Public Utilities Commission and other state agencies and entities. Recognizing that it serves only as a starting point, this report provides a collective expression of the Working Group rather than a record of individual participant positions. In converging on answers, Working Group participants mostly agreed, but the materials, statements, and recommendations do not necessarily represent the statements or recommendations of individual Working Group participants or the stakeholders they represent.

LIST OF ACRONYMS

ADA	Americans with Disabilities Act
AQMD	Air Quality Management District
B2B	Business-to-Business
B2C	Business-to-Consumer
BTM	Behind-the-Meter
C&I	Commercial and Industrial
CAISO	California Independent System Operator
CARB	California Air Resources Board
CCA	Community Choice Aggregator
CEC	California Energy Commission
CESA	California Energy Storage Alliance
CPUC	California Public Utilities Commission
DCFC	Direct Current Fast Charger
DER	Distributed Energy Resource
DERP	Distributed Energy Resource Provider
DOE	Department of Energy
DRAM	Demand Response Auction Mechanism
EDU	Electricity Distribution Utility
EE	Energy Efficiency
EPIC	Electric Program Investment Charge Program (CEC)
ESDER	Energy Storage and Distributed Energy Resources Program (CAISO)
EV	Electric Vehicle
EVSE	Electric Vehicle Service Equipment
FERC	Federal Energy Regulatory Commission
FTM	Front-of-the-Meter
GHG	Greenhouse Gas
GRC	General Rate Case
IDER	Integrated Distributed Energy Resources
IEEE	Institute of Electrical and Electronics Engineers
IOU	Investor-Owned Utility
ISO	Independent Service Operator
kW	Kilowatt
kWh	Kilowatt-hour
LCFS	Low Carbon Fuel Standard
LDV	Light Duty Vehicle
LSE	Load Serving Entity
ME&O	Marketing, Education and Outreach
MHDV	Medium- and Heavy-Duty Vehicle
MUA	Multiple Use Application
MUD	Multi Unit Dwelling
NEC	National Electrical Code
NEM	Net Energy Metering
NGR	Non-Generator Resource
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
OIR	Order Instituting Rulemaking
PDR	Proxy Demand Resource
PEV	Plug-in Electric Vehicle
PG&E	Pacific Gas and Electric
PSPS	Public Safety Power Shutoff
PUC	Public Utility Commission
PV	Photovoltaic
RA	Resource Adequacy
RE	Renewable Energy
RFP	Request for Proposals
SB	(California) Senate Bill
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SFH	Single Family Home
SGIP	Self-Generation Incentive Program
TCO	Total Cost of Ownership
TEF	Transportation Electrification Framework
TNC	Transportation Network Companies
TOU	Time-of-Use
UL	Underwriters Laboratories
V1G	EV unidirectional charging
V2G	Vehicle-to-Grid (bidirectional)
V2H	Vehicle-to-Home (bidirectional)
V2M	Vehicle-to-Microgrid (bidirectional)
VGI	Vehicle-Grid Integration

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EXECUTIVE SUMMARY

Overview

To realize its vision of a carbon-neutral economy, California has set a target of 5 million zero-emission vehicles on the road and 250,000 charging ports in service by 2030 and has expressed an intent to "reduce costs or mitigate cost increases for all ratepayers due to increased usage of electric vehicles by accelerating electric vehicle grid integration…"[1]

A definition of VGI is codified in California Public Utilities Code Section 740.6:

> "Electric vehicle grid integration" means any method of altering the time, charging level, or location at which grid-connected electric vehicles charge or discharge, in a manner that optimizes plug-in electric vehicle interaction with the electrical grid and provides net benefits to ratepayers by doing any of the following: (a) increasing electrical grid asset utilization; (b) avoiding otherwise necessary distribution infrastructure upgrades; (c) integrating renewable energy resources; (d) Reducing the cost of electricity supply; and (e) offering reliability services consistent with Section 380 or the Independent System Operator tariff.

To help realize these goals and methods, the California Independent System Operator (California ISO), California Energy Commission (CEC), California Air Resources Board (CARB), and California Public Utilities Commission (CPUC) jointly created the Vehicle Grid Integration (VGI) Working Group. A 2019 Ruling of the CPUC tasked the Working Group with addressing the following questions:

(a) What VGI use cases can provide value now, and how can that value be captured?
(b) What policies need to be changed or adopted to allow additional use cases to be deployed in the future?
(c) How does the value of VGI use cases compare to other storage or DER?

The VGI Working Group worked collaboratively between August 2019 and June 2020 to address these three questions. The Working Group was made up of diverse representatives of VGI stakeholders, including state agencies, utilities, community choice aggregators, the California ISO, electric vehicle (EV) manufacturers, battery manufacturers, charging network and energy service providers, advocacy and research groups, industry associations, and ratepayer interest groups. The organization Gridworks was engaged to facilitate the Working Group and create this report of its outcomes and recommendations.

Limits of the Report

The Working Group provided extensive perspectives on PUC Questions (a) and (b). However, due to time, data, and expertise constraints, the Working Group could only suggest ways in which the CPUC might pursue answers to PUC Question (c) in the future. The Working Group also faced limitations in getting private-sector cost information and could only assess costs on a relative basis, precluding cost-benefit analysis or assessment of net value. And the Working Group faced limitations in fully assessing barriers to VGI, including customer interest and acceptance, as well as the costs of eliciting participation in VGI programs, such as marketing and dealership education.

[1] See footnotes in the Introduction for all references and citations.

Why VGI Now?

The Working Group was both mandated and motivated by a conviction that VGI affords many potential benefits, including:

- Accelerating the adoption of EVs by providing additional revenue streams that lower the total cost of vehicle ownership for individual owners and fleet operators
- Reducing costs to electricity ratepayers by reducing congestion on existing power distribution infrastructure and costly distribution system upgrades, as well as reducing the need to invest in new fossil-fuel electricity generation
- Supporting further decarbonization of the electric sector by avoiding curtailment of renewables and providing grid services
- Accelerating reduction of carbon and criteria pollutant emissions in the transportation sector
- Improving grid resiliency and security, including for public safety power shutoff (PSPS) events

Opportunities to realize these benefits are available today and will grow rapidly as EV adoption expands. However, much depends on what happens in the next few years, including shaping electricity customers' attitudes towards VGI as more and more customers purchase EVs.

VGI Use Case Definition and Value

As summarized in Section A of this report, the Working Group first collaborated to develop a VGI use case framework to define, screen, evaluate and prioritize potential VGI use cases. Use cases represent the different ways in which EV charging can be integrated with the grid (or home/local power system) to provide value. Use cases help articulate how value streams can flow to different stakeholders, including EV owners and fleet managers, workplaces and other charging site hosts, charging service providers, utilities and CCAs, ratepayers, and grid operators. Use cases can serve as the building blocks for defining, creating and exchanging value from VGI among these stakeholders, and policy-making should recognize that different use cases may require different policies to help realize these value streams.

The framework developed provides a structuring of the potential VGI market. It recognizes comprehensively the key factors shaping VGI: where the vehicle would be charged/discharged, types of vehicles, services that EV charging can provide, power flow to and/or from the vehicle, control mechanisms for charging or discharging, degree of alignment of actions by the vehicle operator and the charger operator, and the characteristics of charging technologies. The Working Group used this framework to systematically explore the universe of VGI potential and answer the first question before the Working Group, **"what VGI use cases can provide value now?"**

What emerged are 320 different VGI use cases that, for the purposes of this report, should be considered as able to provide value by 2022. These use cases address VGI across a wide range of sectors (e.g., residential, commercial, rideshare, and fleets), applications (e.g., for customer bill management, renewable energy integration, or distribution upgrade deferral), approaches to control charging and/or discharging (direct and indirect), and types of charging (V1G and V2G). Both light-duty vehicles (i.e., passenger and ride-share vehicles) and medium- and heavy-duty vehicles (i.e., trucks, buses, and vans) are represented by the use cases.

However, the value perceived by Working Group participants for these use cases varied widely on a broad spectrum. Therefore, it is clear that these 320 use cases should not all be treated equally in policy-making, but should be differentiated across a spectrum of value. Furthermore, many other use cases developed by the Working Group have the potential to provide value in the medium- and long-term.

Answers to the question of how to capture the value of these use cases are addressed by the policy recommendations in Section B of this report.

Defining Key Terminology

V1G is single-direction charging that allows managed charging and flexible demand ("demand response")

V2G (vehicle-to-grid) is bidirectional charging and discharging, allowing vehicles to discharge stored energy back onto the grid or into a building or local power system.

Indirect (passive) control of charging involves adjusting the EV charge/discharge based on time-varying price signals or grid conditions. Charging behavior in response to such signals is not prescribed or commanded, and can occur passively without any response required by an individual customer.

Direct (active) control of charging involves adjusting the EV charge/discharge in response to active external "dispatching instructions" that prescribe or command charging behavior. EV participation in the Demand Response Auction Mechanism (DRAM) would be a good example of active aggregated charging.

Differentiating Among Use Cases

Although the Working Group did not conduct cost-benefit analysis nor rank these use cases explicitly, it did consider several ways to differentiate use cases that were scored highly by the Working Group in terms of benefits, costs, and ease/risk of implementation. Such highly-scored use cases illustrate different aspects of value. However, the Working Group could not differentiate among use cases using cost-effectiveness or net value.

One key differentiator among these potential use cases is the benefits they provide through their applications and control approaches. Many use cases scored highly by the Working Group related to:

- Customer bill management
- Avoiding or deferring investment in upgrading the power distribution grid
- Home and building backup power and resiliency
- Daytime charging to support balancing and storing renewable energy
- Indirect (passive) control approaches, such as time-varying retail rates and responding to informational signals of grid conditions (i.e., carbon signals or real-time wholesale energy prices) that do not require specific customer behavioral responses

The total statewide benefit from a single use case ranged up to an estimated $200 million per year based on scoring of the use cases by Working Group participants (see Section A for scoring details).

While the Working Group recognized the challenge of simultaneously advancing 320 use cases, ***an important result is that there are many potential VGI use cases that can provide value, and that the potential market for VGI solutions is diverse and interwoven across a broad swath of the transportation and power sectors.*** Given the use case assessment work performed by the Working Group, it appears that the work of developing markets for VGI solutions will demand persistent action for the next several years. ***California should take an inclusive and collaborative approach to VGI opportunities given the evolving nature of the regulatory and market landscape.***

Focus on V2G and on Medium- and Heavy-Duty Vehicles

There are several key ways to differentiate use cases within the VGI landscape that give shape to the Working Group's policy recommendations, including V2G as distinct from V1G, medium- and heavy-duty as distinct from light-duty. Light-duty V1G use-cases such as residential customers charging at single-family homes on time-varying rates are generally more familiar. The Working Group made a conscious effort to explore and promote medium- and heavy-duty and V2G use cases. Through this effort the Working Group recognized the benefits unique to these use cases and emphasized recommendations to overcome barriers for them.

Policy Recommendations

The Working Group built off its successful definition and valuation of VGI use cases to consider the second question before the Working Group, **"what policies need to be changed or adopted to allow additional use cases to be deployed in the future?"** The overriding intent of this process was to create actionable specific recommendations for consideration by California's state agencies, investor-owned utilities, community choice aggregators, the California ISO, and others.

As summarized in Section B of this report, the Working Group developed a set of 92 individual recommendations for policy actions that California state agencies, utilities, community choice aggregators, and CAISO could undertake to advance VGI in the short-term (2020-2022), medium-term (2023-2025), and long-term (2026-2030). These recommendations are separated into 11 different policy categories. Together, these 11 categories broadly address virtually all aspects of policy support for the VGI use cases:

#	Category
1	Reform retail rates
2	Develop and fund government and LSE customer programs, incentives, and DER procurements
3	Design wholesale market rules and access
4	Understand and transform VGI markets by funding and launching data programs, studies and task forces
5	Accelerate use of EVs for bi-directional non-grid-export power and PSPS resiliency and backup
6	Develop EV bi-directional grid-export power including interconnection rules
7	Fund and launch demonstrations and other activities to accelerate and validate commercialization
8	Develop, approve, and support adoption of technical standards not related to interconnection
9	Fund and launch market education & coordination
10	Enhance coordination and consistency between agencies and state goals
11	Conduct other non-VGI-specific programs and activities to increase EV adoption

Of the 92 policy recommendations made by the Working Group, the following 23 constitute the most urgent recommendations with the strongest level of agreement by a majority of participants:

Category	Policy Recommendations (*)
1	Create an "EV fleet" commercial rate that allows commercial and industrial customers to switch from a monthly demand charge to a more dynamic rate structure
2	Require utilities to broadcast signals to a DER marketplace of qualified vendors (curtailment and load) V2G systems become eligible for some form of SGIP incentives Enable customers to elect BTM load balancing option to avoid primary or secondary upgrades, either if residential R15/16 exemption goes away, or as an option for non-residential customers Consider coordinated utility and CCA incentives for EVs, solar PV, inverters, battery storage, capacity, and EV charging infrastructure to support resilience efforts in communities impacted by PSPS events Allow V1G and V2G to qualify for SGIP to level the playing field with incentives for other DERs, but V1G would get less incentive compared to V2G based on permanent load shift logic Incentive(s) for construction projects with coincident grid interconnection and EV infrastructure upgrade Enable customers, via Rules 15/16 or any new EV tariff, to employ load management technologies to avoid distribution upgrades, and focus capacity assessments on the Point of Common Coupling
4	Use EPIC, ratepayer, US DOE, and/or utility LCFS funds for an on-going, multi-year program to convene VGI data experts to study lessons learned, quantify VGI/DER net value, fund new data sources, and address other topics
5	Pilot funding for EV backup power to customers not on microgrids, including state-wide goals for at least 100 EVs by 2021 and 500 EVs by 2022; utilities to consider the feasibility of EVs for emergency backup generation in PSPS plans and resiliency solutions
6	Pilot funding for V1G and V2G for microgrid and V2M solutions, including a state-wide near-term goal; and utilities’ PSPS plans and microgrid frameworks should consider EVs for FTM grid services
7	Focusing on resiliency and backup application in workplace and multi-unit dwellings, leverage EPIC funding to pilot use-cases to understand and reduce costs and to streamline implementation. Create pilots to demonstrate V2G's ability to provide the same energy storage services as stationary systems and let V2G systems participate in pilots for stationary storage Special programs and pilots for municipal fleets to pilot V2G as mobile resiliency Demonstration to define the means to allow aggregators, EV network providers, and charge station operators to dynamically map the capacity and availability of EVSE resources, using open standards Use EPIC, ratepayer, USDOE, and/or utility LCFS funds ($50M) in many competitively bid large-scale demonstrations of promising VGI use cases to provide data needed to scale up VGI efforts (e.g., validate consumer acceptance, incentive levels, security, net value, and communication pathways) Study to understand the impact on the distribution grid and generation system from EVs based on over ten existing/planned mandates from CARB & AQMDs to meet California 2045 carbon neutral goal
9	Create public awareness and education programs and materials on V2G systems and how to get them. This could particularly be focused toward government fleets Optimize CALGreen codes for VGI and revise to require more PEV-ready parking spaces and expand to existing buildings
10	State agencies coordinate and maintain consistency on TE and VGI across the different policy forums with no duplication of regulation, clear roles and vision on VGI and priority on state TE goals over VGI Incentivize use of multiple open standards for VGI communication, charging networks, cloud aggregators, and site hosts
11	Streamline permitting for charging infrastructure Create Incentives for charging infrastructure for new public parking lot construction projects

(*) This table is based on Table 9 in Section B, “Short-Term Policy Recommendations with Strong Agreement.”

These policy recommendations, along with the many others also described in this report and supported by participants, reflect the strength and diversity of the Working Group's recommendations on:

- V1G and V2G
- Light-, medium-, and heavy-duty vehicles
- Short-, medium-, and long-term
- Actions needed by individual agencies or LSEs and those requiring collaboration across jurisdictions

Section B gives a full account of all policy recommendations, as well as valuable dissenting perspectives. Annex 1 provides links to the full set of materials developed by the Working Group, which include extensive additional information on the policy recommendations, such as full descriptions, further comments, metrics, strategies, lead and supporting agencies/entities, barriers, and relevant use cases.

Valuing VGI Relative to Other Distributed Energy Resources

The Working Group was challenged by the third question, "**how does the value of VGI use cases compare to other storage or DERs?**" and does not offer a complete response at this time. Challenges included:

- Limited insight into the costs of VGI resources and limited availability of cost data
- Limited expertise by many participants in storage and other DERs
- Lack of time and resources to conduct the necessary quantitative analytics and literature reviews
- Lack of a developed framework and analysis criteria to make true "apples-to-apples" comparisons

While the Working Group could not respond in full, Section C of this report contributes substantially to resolving this question by organizing the challenges and potential approaches to achieving resolution. Further efforts to compare VGI use cases with other DERs can recognize and incorporate the wealth of work and perspectives on VGI use cases produced by the Working Group.

Next Steps

The VGI Working Group is proud to present this report and associated materials. Working Group participants were motivated by a conviction that VGI affords many potential benefits. Many opportunities to realize these benefits are available today and will grow rapidly as EV adoption expands, as shown by the extensive work completed by the Working Group on use case assessment and policy recommendations. This work provides a solid foundation for the next stages of VGI in California, and the Conclusion section of this report provides a number of clear next steps.

The high degree of cooperation and collaboration achieved among 85 participating organizations and individuals during the ten-month course of the Working Group also demonstrates that VGI is a unique and effective convening umbrella or venue for fostering collaboration between the electric power and EV/charging sectors, and among many types of industry, government, advocacy, research, and utility and CCA stakeholders.

The VGI Working Group, consisting of participants voluntarily contributing their limited time and resources, commends this report to the leaders of the California ISO, CEC, CARB, and CPUC. We ask for thoughtful consideration of these recommendations and a timely response to this plea.

INTRODUCTION

To realize its vision of a carbon-free economy, California has set a target of 5 million zero-emission vehicles on the road and 250,000 charging ports in service by 2030.[2] California has also expressed an intent to "reduce costs or mitigate cost increases for all ratepayers due to increased usage of electric vehicles by accelerating electric vehicle grid integration."[3] Today California already leads the nation in electric vehicle (EV) adoption with over 700,000 EVs on the road.[4]

Fueling millions of EVs is both a challenge and an opportunity for California's grid and customers. The California Independent System Operator (California ISO), California Energy Commission (CEC), California Air Resources Board (CARB), and California Public Utilities Commission (CPUC), along with other state agencies and organizations, have each invested significant effort to investigate how EVs can be best integrated with the electric grid.[5]

One key focus of California state agencies has been to understand how to integrate incremental electric vehicle load in a way that creates value to the grid, to utilities, and to customers, and identify strategies to capture and scale that value. If charging occurs during existing peak periods, California may (1) need to invest in new distribution infrastructure and generation, (2) face new grid operational challenges, and (3) see increased emissions from the electric sector.[6] Conversely, charging behavior that avoids peak periods in favor of times that are optimal to both the customer and the grid presents an opportunity. If EV load can be managed or vehicles can be configured to export power to the grid, new investment, operational challenges and emissions increases can be avoided, all while reducing emissions from the transportation sector and providing new, more affordable mobility.

There are also challenges and opportunities for EVs in the context of wildfire risk and California's Public Safety Power Shutoffs (PSPS). Some customers may be hesitant to adopt EVs for fear that charging during an outage would be impossible. Other customers may see an opportunity, using Vehicle-to-Building (V2B) technology to provide onsite backup power or Vehicle-to-Grid (V2G) options to support grid resilience.

Opportunities for integrating EVs with the grid have collectively been called Vehicle Grid Integration (VGI). California's Public Utilities Code Section 740.16 defines VGI as follows: [7]

> "Electric vehicle grid integration" means any method of altering the time, charging level, or location at which grid-connected electric vehicles charge or discharge, in a manner that optimizes plug-in electric vehicle interaction with the electrical grid and provides net benefits to ratepayers by doing any of the following: (a) Increasing electrical grid asset utilization; (b) Avoiding otherwise necessary distribution infrastructure upgrades; (c) Integrating renewable

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[2] Executive Order B-48-18; https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html
[3] California Public Utilities Code Section 740.6 (a)(D)(2)
[4] https://www.veloz.org/wp-content/uploads/2020/02/12_Q4_2019_Dashboard_PEV_Sales_veloz.pdf
[5] https://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf; https://www.cpuc.ca.gov/vgi/; https://www.energy.ca.gov/programs-and-topics/programs/california-vehicle-grid-integration-roadmap-update
[6] Vehicle-Grid Integration Initiative 4/12/19; https://gridworks.org/wp-content/uploads/2019/05/VGI_4.12-Slides.pdf
[7] California's Public Utilities Code Section 740.16; https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB983

energy resources; (d) Reducing the cost of electricity supply; (E) Offering reliability services consistent with Section 380 or the Independent System Operator tariff" [8]

VGI can include a range of solutions, from passive interventions such as time-varying (or time-of-use) electricity rates that give customers pricing signals to incentivize or disincentivize charging during specific time windows, to active solutions that leverage the EV's battery to modulate the vehicle's charge or discharge into the grid. VGI has the potential to provide a wide range of benefits for the adopting customers, electricity ratepayers, their electricity service providers, grid operators, and the overall environment and society.

<u>Scoping of the VGI Working Group</u>

As part of California's continuing policy-making efforts for accelerating the adoption of EVs and for realizing the multiple benefits of EVs, the CPUC instituted in 2018 an Order Instituting Rulemaking (OIR) to Continue the Development of Rates and Infrastructure for Vehicle Electrification (R.18-12-006), also called the "DRIVE OIR."[9] An associated May 2, 2019 Scoping Ruling and Memo ordered a new interagency, multi-stakeholder VGI Working Group to focus on identifying the costs and benefits of VGI use cases, tied to the goals set forth in the 2018 OIR.[10]

The Working Group was scoped to evaluate use cases for direct and indirect managed charging, including use cases for single-direction charging for responding to time-varying rates and dispatched demand-response (commonly referred to as V1G), bidirectional use cases in which vehicle batteries can discharge stored energy back onto the grid (vehicle-to-grid or V2G), and bidirectional use cases in which vehicle batteries discharge only behind-the-meter (vehicle-to-building/home or V2B/V2H).[11] As directed in the R.18-12-006 Scoping Ruling, the Working Group was to, at a minimum, cover the following questions:

(a) What VGI use cases can provide value now, and how can that value be captured?
(b) What policies need to be changed or adopted to allow additional use cases to be deployed in the future?
(c) How does the value of VGI use cases compare to other storage or DER?

The Working Group collaborated between August 19, 2019 and June 30, 2020 developing, discussing, and converging on answers to these three questions (henceforth called "PUC Questions"). Over 85 organizations and individuals actively participated, including state agencies, investor-owned utilities (IOUs), community choice aggregators (CCAs), municipally owned utilities (MOUs), the California ISO, EV manufacturers, battery manufacturers, charging network and energy service providers, advocacy groups, industry associations, research and academic institutions, and ratepayer interest groups. This

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[8] SB 676; http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200SB676
[9] R.18-12-006 Development of Rates and Infrastructure for Vehicle Electrification and Closing OIR; https://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=252025566; this rulemaking followed a 2017 "VGI Communications Protocol Working Group" as noted in the DRIVE OIR, during which parties requested that the working group process be continued, leading to the present Joint Agencies VGI Working Group scoped in the DRIVE OIR.
[10]May 2, 2019 Scoping Ruling and Memo; https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M285/K712/285712622.PDF
[11] Ibid. Managed charging is defined here as a coordinated shift/modulation of the time or level of EV charging or discharging in response to a variety of possible external signals, either passively or actively. Other literature may take a narrower view of the meaning of managed charging, such as limiting it to direct (active) control only.

level of participation, expertise, and perspectives was fundamental to the success of the Working Group. The organization Gridworks, an experienced facilitator on VGI and DERs more broadly in California and elsewhere, facilitated the process.

Participants contributed through a regular series of workshops, conference calls, submissions of materials, and reviews. A broad range of experts and stakeholders conducted use case assessment, including group-based and individual-based use-case screening and scoring, developed policy recommendations, and took part in an extended survey on the policy recommendations. All together this generated hundreds of recommendations and tens of thousands of individual data points on participant assessments, opinions, and comments.

Community Choice Aggregation and VGI

Community Choice Aggregators (CCAs) participated actively in the Working Group, supporting the creation of recommendations for all Load Serving Entities (LSEs). As nonprofit public entities governed by the cities, counties and towns that they serve, CCAs now represent a large driver of clean energy in California. As electricity suppliers to public sector, residential, business and industry customers, CCAs possess relevant customer data and are using that data to inform programs for transportation electrification. As CCAs continue to expand their transportation electrification programs, coordination and planning between CCAs and IOUs on VGI will be essential.

Limits of the Report

The Working Group provided extensive perspective on PUC Questions (a) and (b). However, due to time, data, and expertise constraints, the Working Group could only suggest ways in which the CPUC might pursue answers to PUC Question (c) in the future.

This report does not address every aspect of VGI, but rather provides a starting point for further rulemaking, policy, and programs for VGI by the CPUC and other state agencies. Recognizing that it serves only as a starting point, this report provides a collective expression of the Working Group rather than a record of individual participant positions. In converging on answers, Working Group participants mostly agreed, but the materials, statements, and recommendations do not necessarily represent the statements or recommendations of individual Working Group participants or the stakeholders they represent.

While focusing on the three PUC Questions, the Working Group deemed some issues out of scope or beyond its ability and time to address, including: net-benefit analysis that directly compares benefits to costs; realistic detailed cost data on use cases; comprehensive treatment of barriers to VGI; and customer acquisition expenses and outreach needed to get customers to participate in VGI programs (e.g., incentives, marketing, dealership education).

Stages of the Working Group and Connection to Other VGI Efforts

Over the ten-month period the Working Group proceeded in four distinct stages (Table 1). The materials produced by the Working Group over these four stages are mapped and linked in Annex 1. The process through which the Working Group developed these materials is described in Annex 2. And further reference material is provided in Annex 3. In addition to answering PUC Questions (a) and (b), the Working Group produced a great wealth of materials containing recommendations, comments, frameworks, and perspectives on VGI for the short-, medium-, and long-term.

The VGI Working Group conducted its work with the full recognition of the many other ongoing and planned efforts by California state agencies and other entities to address transportation electrification.[12] These include the new mandates of California Senate Bill (SB) 676 for supporting transportation electrification to 2030[13], the Transportation Electrification Framework[14], an updated CEC VGI Roadmap in progress[15], CALGreen building code updates[16], SGIP program revisions[17], the Rule 21 interconnection proceeding[18], the microgrids proceeding[19], CPUC rates proceedings[20], CEC EPIC funding[21], and many initiatives by private entities, IOUs, CCAs, and other Load Serving Entities (LSEs).

Table 1: Four Stages of the VGI Working Group

Stage	Dates	Materials Produced
1. Methodology	8/19/19-10/31/19	Developed and agreed upon a basic use case assessment framework and methodology that defines over 2500 potential VGI use cases.
2. Use case assessment: PUC Question (a)	9/30/19-1/30/20	Identified and screened 1060 distinct use cases that could potentially provide value, using screens for technological feasibility, market maturity, customer acceptance and adoption, and data availability. Scored use cases that passed screening in terms of benefits, costs, and ease/risk of implementation. Identified over 300 use cases deemed to provide value in the short-term to 2022, and many additional use cases that could potentially provide value in the medium- and long-term.
3. Policy recommendations: PUC Question (b)	1/31/20-6/4/20	Developed and consolidated policy recommendations into a set of 92 discrete recommendations in 11 categories with extended supporting descriptions and accompanying state agency and CAISO comments. Then surveyed participants on their agreement with these recommendations, the clarity and relevance of the recommendations, and further written comments, receiving over 9,000 survey datapoints.
4. DER comparisons: PUC Question (c)	4/16/20-5/15/20	Suggested further action by the PUC in comparing VGI use cases with other DER use cases, but did not provide an answer to PUC Question (c).

[12] Among the materials generated by the Working Group were "stock-takes" of existing efforts by state agencies, the California ISO, and CCAs; see links in Annex 1.
[13] SB676 ; https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200SB676
[14] SB 350 Transportation Electrification Programs; https://www.cpuc.ca.gov/sb350te/, (D.18-05-040); https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442457637
[15] CEC VGI Roadmap; https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=18-MISC-04
[16] CALGreen (CCR, Title 24, Part 11); https://www.dgs.ca.gov/BSC/Resources/Page-Content/Building-Standards-Commission-Resources-List-Folder/CALGreen
[17] SGIP; https://www.cpuc.ca.gov/sgip/
[18] Rule 21 Interconnection Proceeding (R.17-07-007); https://www.cpuc.ca.gov/Rule21/
[19] Microgrids OIR (19-09-009); https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M314/K274/314274617.PDF
[20] Zero Emission Vehicle Rate Programs; https://www.cpuc.ca.gov/General.aspx?id=12184
[21] CEC Electric Program Investment Charge Program; https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program

Why Is VGI Important?

At the end of the Working Group, participants were asked why they had participated and why they thought that effort on VGI was worthwhile. Some responses were:

> VGI can provide key, material benefits to the EV driver: from financial incentives/rewards that help to lower the total cost of ownership, to confidence and assurance that their charging needs will be taken into account across all charging venues, to helping align their EV charging with renewable availability (appeals to the 'green' conscience). In this way, we see VGI as a key element in helping to enable and accelerate EV adoption. –Ford
>
> Intelligently marrying electric vehicles and the grid offers a significant opportunity to unlock value and benefits for EV drivers, ratepayers, industry stakeholders, and society overall. –General Motors
>
> VGI allows us to maximize the value of our EV charging technologies we are able to deliver to drivers, site hosts, utilities, and grid operators. –Enel X
>
> VGI is an integral part of ensuring that transportation electrification is clean, affordable, resilient, and simple. VGI should be proactively and thoughtfully included in transportation electrification strategies, plans, programs, and projects. VGI is also a key venue for automakers, utilities, charging providers, and others to come together to ensure a successful transition to the mobility future we seek. –ENGIE Impact
>
> Our interest lies in developing the electric transportation market. We want to do everything possible to reduce barriers to adoption during its growth phase. Through VGI, both the EV driving public and ratepayers will ultimately benefit. –Southern California Edison

The Working Group took note of the many benefits that VGI can provide. The comments above point to benefits that can include lowering total ownership costs for EV owners and fleet operators by providing additional revenue streams; reducing costs to electric ratepayers by limiting congestion on existing distribution infrastructure, the need for new fossil generation resources, and costly distribution system upgrades; supporting further decarbonization of the electric sector by avoiding curtailment of renewables and providing grid services; and accelerating reduction of carbon and criteria pollutant emissions from the transportation sector. Many other potential benefits are explained in Working Group materials and referenced literature provided in Annexes 1 and 3.

The Working Group also noted the ubiquitous nature of VGI potential across all customers and businesses, given the acceleration of EV adoption, and the unique role of VGI in fostering EV adoption. That is, VGI can reduce the total cost of ownership of electric vehicles, unlock new value propositions and revenue streams, and facilitate charging infrastructure investments. VGI-enabled EVs can also provide grid reliability services and help limit overall electricity system cost increases by providing lower-cost alternatives to traditional supply-side resources, and by mitigating the cost impacts of rising EV and renewable energy adoption.

And the Working Group also took note of several potentially unique attributes of VGI that can distinguish VGI from other traditional DERs and also provide complementary benefits to traditional DERs, although further understanding and experience is needed to confirm these attributes:[22]

- **Ubiquity.** EVs will become ubiquitous so applications and benefits can apply to a broad segment of utility customers, workplaces, and destinations.
- **Simplicity.** For at least some use cases, load flexibility via VGI may be relatively simple to implement, for example a smart charger that responds to time-varying price signals.
- **Fast and flexible response.** Charging may be able to respond quickly to event or price signals to provide high-capacity real-time flexibility for serving grid needs such as balancing renewable energy intermittency and supporting intra-day ramping.
- **Load shift capacity.** Residential charging represents long-duration loads that are generally quite able to shift given how long cars are parked and be responsive to TOU rates.
- **Leveraging of EV investments.** Investment in EVs themselves yields clean transportation benefits independent of VGI. VGI solutions can be incremental or additional in leveraging existing or planned investments in EVs and charging infrastructure.
- **Multiple benefit streams.** There is also the potential for "value stacking" in which multiple benefits or applications can be accrued simultaneously or at different times of day, so that there are multiple potential value streams from a single investment.
- **Resiliency.** There are unique resiliency benefits, at both the building-level and community-level, to counteract Public Safety Power Shutoffs (PSPS).
- **Locational flexibility.** EVs can respond to location-specific grid needs, as EVs in different locations can flexibly offer charging or discharging resources to the grid.
- **Cross-industry collaboration.** VGI is also a unique and effective convening umbrella or venue for fostering collaboration among entities in the electric power and EV/charging industries.

Senate Bill 676 and the VGI Working Group

During the course of the Working Group, Senate Bill (SB) 676 was enacted by the California legislature. SB 676 adds a new section 740.16 to the Public Utilities Code on the subject of transportation electrification. With the passage of SB 676, the CPUC, CEC, and other state agencies assumed further responsibilities with regard to charting and developing VGI policy in California to 2030. Per SB 676, "the commission shall establish strategies and quantifiable metrics to maximize the use of feasible and cost-effective electric vehicle grid integration by January 1, 2030."[23]

Although the scope of the VGI Working Group did not change in response to the passage of SB 676, the broad mandate of PUC Question (b) on policy recommendations allowed the Working Group to think longer term to 2030. The use cases identified by the Working Group are also relevant to the longer-term. The use case assessments described in Section A and the policy recommendations described in Section B should be considered by the CPUC as it provides guidance for California's regulated utilities to comply with the VGI requirements established in Public Utilities Code section 740.16.

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[22] These bullets stem from a "targeted discussion" of the Working Group, but were not substantiated with data nor endorsed by the full Working Group as currently presented.

[23] SB 676; http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200SB676

SECTION A. PUC QUESTION (A): WHAT VGI USE CASES CAN PROVIDE VALUE NOW, AND HOW CAN THAT VALUE BE CAPTURED?

Use cases represent the different ways in which EV charging can be integrated with the grid (or home/local power system) to provide value. Use cases help articulate how value streams can flow to different stakeholders, including EV owners and fleet managers, workplaces and other charging site hosts, charging service providers, utilities and CCAs, ratepayers, and grid operators. Use cases can serve as the building blocks for defining, creating and exchanging value from VGI among these stakeholders, and policy-making should recognize that different use cases may require different policies to help realize these value streams.

The Working Group put forth 320 use cases which, for the purposes of this report, should be considered as "able to provide value now."[24] These use cases are given in Annex 5. Most Working Group participants agreed that no scored use case should be excluded from being considered as "able to provide value now," since all use cases that passed screening and received a benefit score indicated at least some value.[25]

However, the value perceived by Working Group participants for these use cases varied widely on a broad spectrum, when benefits, costs, and the ease and riskiness of implementation (related to barriers and many other factors) are taken into account. Therefore, it is clear that these 320 use cases should not all be treated equally in policy-making, but should be differentiated across a spectrum of value. Furthermore, many other use cases developed by the Working Group beyond these 320 use cases have the potential to provide value in the medium- and long-term.

Although the Working Group did not prioritize or rank these use cases explicitly, it also put forth a number of smaller groupings of these 320 use cases ("subsets") that were scored highly by the Working Group in terms of benefits, costs, and ease/risk of implementation. And although the Working Group did not choose any single one of these subsets to recommend above any other, the subsets nevertheless show different aspects of value and present a robust overview. Most Working Group participants also agreed that the answer to "how can that value be captured" is answered by the policy recommendations put forth in Section B, also considering the specific use cases to which a given policy could apply.

In order to assess use case value and answer PUC Question (a), one of the first tasks of the Working Group was to define and adopt a framework and methodology for assessing VGI use cases. The dimensions of the framework were purposely defined to be of most relevance to policy making, capturing those aspects of use cases that can be connected to, or are supported by, particular policy

[24] The 320 use cases are those receiving at least at least a partial benefit score from the scoring process described later in this section. This means that at least one participant scored the use case for benefits, either for the $/EV/year benefit metric, and/or for the metric total population of EVs that could participate by 2022. There was some debate about whether use cases scored on only one of these metrics be excluded, since the full benefit of multiplying the two metrics together could not be obtained, most participants agreed to include the use case if only one of these metrics was scored. Also, the conclusion that all use cases with benefits should, for the purposes of this report, be considered as "able provide value now" should only be interpreted as an answer to PUC Question (a), and does not imply that programs to enable these use cases necessarily maximize benefits and minimize costs.

[25] The conclusion that all use cases with benefits should, for the purposes of this report, be considered as "able to provide value now" should only be interpreted as an answer to PUC Question (a), and does not imply that programs to enable these use cases necessarily maximize benefits and minimize costs.

strategies. The framework also provides a foundation for connecting use cases to specific business models, although the Working Group in assessing use case value for PUC Question (a) did not consider business models associated with use cases.

The framework adopted by the Working Group consists of six dimensions for characterizing a use case. These are:

1. Sector. The Sector pinpoints where the vehicle is used and charged/discharged. It could be broadly grouped into residential and commercial categories, or subsets thereof (e.g. commercial school bus, or commercial public destination). The Working Group decided to employ 13 options for Sector.

2. Application. The Application refers to the service(s) VGI aims to provide. Applications can be broadly grouped into “customer applications” that focus on services to the electricity customer and/or EV owner/operator, and “system applications” that focus on services to the grid. While the prospect of “stacking” applications and their values is important, such that multiple applications and services can be delivered, the framework clarifies that “customer applications” and “system applications” should be treated separately and not stacked. The Working Group decided to employ 17 options for Application.

3. Type. The Type determines the power flow to and/or from the vehicle, whether uni-directional (V1G) or bi-directional (V2G). In this framework, “V2G” represents all bidirectional types including power flow exporting from the vehicle that may not reach the grid, such as for non-export “vehicle-to-home” (V2H) and “vehicle-to-building” (V2B) use cases.

4. Approach. Approach refers to the mechanism through which the vehicle’s charge and/or discharge is controlled. Approach can be either indirect (passive) control or direct (active) control:

- Indirect (passive) control of charging involves adjusting the EV charge/discharge based on time-varying retail price signals or signals of grid conditions (i.e., carbon signals or real-time wholesale prices). Charging behavior in response to such signals is not prescribed or commanded, and can occur passively without any active response required by an individual customer.

- Direct (active) control of charging involves adjusting the EV charge/discharge in response to active external “dispatching instructions” that prescribe or command charging behavior. Aggregated charging and demand-response programs are good examples. The instructions may directly command charging behavior or may prescribe how to respond to other received signals such as time-varying prices or grid conditions.

5. Resource Alignment. Resource Alignment specifies whether the “EV actor” and the “EVSE actor” are “unified” meaning both the EV and EVSE are controlled and/or operated by the same actor, or “fragmented” meaning controlled and/or operated by different actors. If they are fragmented, then Resource Alignment further specifies whether the separate actors are “aligned” or not, meaning whether their intentions and incentives coincide or are different. Fragmented and misaligned use cases present the greatest potential for barriers. The “EV actor” is the party that controls and/or operates the electric vehicle, and “EVSE actor” is the party that controls and/or operates the electric vehicle charger under the utility meter. There are three logical options for Resource Alignment, shown in Table 2.

6. Technology. Technology identifies the hardware and software needed to realize the VGI opportunity. Technology considerations include, but are not limited to electric vehicle type, charging rate, charging type (e.g. AC with mobile inverter, DC with stationary inverter), and communication requirements and pathways to EV and/or EVSE.

For each of the first five dimensions, the Working Group defined a specific set of options that could be chosen to define a given use case (Table 2).

Table 2. Dimensions of the Use Case Assessment Framework and Use-Case-Definition Options

Sector	Application	Type	Approach	Resource Alignment
Residential-Single-Family Home	Customer-Bill Management	V1G	Indirect (passive)	Unified and Aligned
Residential-Single-Family Home, Rideshare	Customer-Upgrade Deferral	V2G	Direct (active)	Fragmented and Aligned
Residential-Multi-Unit Dwelling	Customer-Backup, Resiliency			Fragmented and Misaligned
Residential-Multi-Unit Dwelling Rideshare	Customer-Renewable Self-Consumption			
Commercial-Workplace	System-Grid Upgrade Deferral			
Commercial-Public, Destination	System-Backup, Resiliency			
Commercial-Public, Destination Rideshare	System-Voltage Support			
Commercial-Public, Commute	System-Day-Ahead Energy			
Commercial-Public, Commute Rideshare	System-Real-Time Energy			
Commercial-Fleet, Transit Bus	System-Renewable Integration			
Commercial-Fleet, School Bus	System-GHG Reduction			
Commercial-Fleet, Small Truck (class 3-5)	System-RA, System Capacity			
Commercial-Fleet, Large Truck (class 6-8)	System-RA, Flex Capacity			
	System-RA, Local Capacity			
	System-Frequency Regulation Up/Down			
	System-Spinning Reserve			
	System-Non-Spinning Reserve			

For the sixth (technology) dimension, for medium-duty and heavy-duty vehicles (MHDV), the sector dimension covered the basic vehicle type -- large truck (class 6-8), small truck (class 2-5), airport shuttle bus, school bus, short-range transit bus, long-range transit bus, and transit shuttle van. However, the Working Group recognized that these four sectors needed to be further delineated for use case development and screening, given the multitude of potential MHDV vehicle and service types. Thus, the Working Group extended the technology dimension for MHDV to include the sub-type of vehicle and the type of service for which it is employed. That is, trucks and buses were optionally delineated into several specific technology variants by battery capacity, charger power, duty cycle, average mileage per route, daytime vs. nighttime charging, and other technology notes. This resulted in a number of discrete technology options (such as “Large Truck A”) when defining MHDV use cases. The MHDV sectors and vehicle types are diverse and such delineation was considered important for scoring. A similar delineation of discrete technology options was not done for LDV use cases.[26] See Annex 4 for further details.[27]

Steps to Assess Use Case Value

The process adopted by the Working Group to assess use case value within this framework consisted of four steps.[28] The Working Group methodically went through each of these steps. The results are described below. See Annex 4 for more details of this process.

Step (a) Identify use cases potentially providing value
Step (b) Screen use cases based on whether seven criteria for providing value are met
Step (c) Score use cases in terms of potential benefits, costs, and ease/risk of implementation
Step (d) Rank use cases based on the scoring results of Step (c)

Step (a) Use case development (submissions from participants). Participants were invited to submit any number of use cases they believed should be considered, by providing the five dimensions of a specific recommended use case from those shown in Table 2. There were a total of 2,652 possible use cases to choose from in making submissions, defined by all possible permutations. In total, nineteen Working Group participants submitted a total of 1,060 unique use cases. The submitted use cases considered sectors, applications, types, approaches, and vehicle types and technology characteristics that could potentially provide value in the short-term ("now") timeframe to 2022, consistent with PUC Question (a).[29] However, the Working Group recognized that many of the submitted use cases, and many that were not submitted, could provide value in the medium- and long-term beyond 2022. It was particularly difficult to identify MHDV use cases for the medium- and long-term, given the many newly emerging types of electric MHDVs. Submitted use cases are available to view and download in the Use Case Assessment Database.[30]

Step (b) Screening. All 1,060 submitted use cases were then screened as either "pass" or "fail" for the short-term ("now") timeframe to 2022. This was done according to the methodology's seven screens for technological feasibility (Screen 1), wholesale and retail market participation rules (Screens 2a-2b),

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[26] Different charger power levels were defined as technology variants for a handful of the LDV use cases; and ranges of battery capacity were noted for many of the use cases. However, the variations were much narrower and less diverse for LDVs than for MHDVs, in part due to the more standardized mass-market nature of LDVs.
[27] For more background on MHDV use cases, see also the white paper developed as part of the Working Group, "Development of Market Analysis and Use-Cases for Medium & Heavy-Duty Vehicle- Grid Integration," linked in Annex 1.
[28] The original methodology developed by the Working Group consisted of six steps, the first being the selection of the framework and the sixth being creating policy recommendations. The first step on selection of the framework is documented in the material provided in Annex 1 and further explained in Annex 2. This "first step" is not elaborated here because the focus of this report is on answering the PUC Questions and not on developing a methodology. The sixth step of the methodology is covered by the work described in Section B. The four steps (a)-(d) outlined here correspond to Steps 2-5 of the formal methodology referenced in Annexes 1 and 2.
[29] PUC Question (a) asks for use cases that can provide value "now." The Working Group engaged in considerable discussion of the meaning of "now" during the use case submission, screening, and scoring steps, and confirmed an understanding that "now" was the short-term period 2020-2022 for purposes of use case assessment. Beyond "now," the Working Group defined "medium-term" as 2023-2025 and "long-term" as 2026-2030 for the purposes of policy recommendations in Section B.
[30] The Use Case Assessment Database is available online at https://airtable.com/shrHTfpCQ7lFjFY9l. Database tables can be viewed and downloaded from that link, and Excel versions are also available directly via the links in Annex 1.

consumer adoption/acceptance (Screens 3a-3b), and availability of data needed to assess the use case (Screens 4a-4b). If a use case passed all seven screens, it was then scored by the Working Group in Step (c). The screening criteria were developed specifically in relation to PUC Question (a) as providing value in California by 2022. The screening resulted in 355 use cases "passing" as potentially providing value by 2022.[31] There were also over 1000 individual comments on screening of individual use cases, for example to explain reasons for failing particular screens or to provide supplementary information. Screening results and comments are available to view and download in the Use Case Assessment Database.[32]

Step (c) Scoring. The use cases that passed screening were then "scored" on their relative benefits, costs, and ease/risk of implementation:

- Benefits were scored according to two parameters: (1) The estimated benefit in dollars per EV per year from VGI for the use case, and (2) the estimated aggregate number of vehicles ("population") that could participate in that VGI use case by 2022.[33] Participants conducting the scoring were asked to rate a given use case using five pre-defined ranges for each parameter, see Annex 4 for the specific ranges. The assessed total benefit score for each use case ($/year as a state-wide aggregate) was the product of these two parameters.[34] Note that the population dimension for benefits reflects technical potential of the total vehicles with technical capability to participate in VGI programs or incentives, not the actual number of vehicles that would be participating, which also requires considering factors like customer education, marketing effectiveness, and adoption rates, factors the Working Group was not able to consider.

- Costs were scored on a relative scale of 1-5 for "very high" to "very low" costs. During the scoring step, there was considerable discussion of the availability of cost data and the need to score costs on a relative rather than an absolute basis in the absence of cost data.[35] The Working Group decided to employ relative cost scoring because absolute costs for various use cases were difficult to obtain given time and confidentiality constraints – some of the private-sector participants said they were unable to share cost information for a number of reasons, including anti-trust and competitiveness concerns. This also meant that the Working Group could not make true cost-benefit comparisons for the use cases because costs were only scored on a relative basis. A number of policy recommendations in Section B support further work on cost data and cost-benefit comparisons.

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[31] Note that some of the use cases that passed screening were designated as "disputed passes" by the Working Group. This meant one participant or scoring team deemed the use case to pass, and at least one other participant or scoring team deemed it to fail. See the "Stage 1 Report" linked in Annex 1 for details.

[32] See Footnote 30.

[33] The scoring of benefits of each use case was based on either customer benefits for customer applications, or system benefits for system applications. System benefits include benefits to ratepayers, and could account, for example, for avoided power system upgrade costs, as well as potential downward pressure on electricity rates to the benefit of all customers as through the acceleration of EV adoption and resulting increase in electricity sales. The factors taken into account by participants in scoring use cases were partially but not fully documented in their comments on scoring, which are available online (see Annex 1 for links to Working Group materials).

[34] Total benefit score was the logarithm of the average $/vehicle/year score for a given use case times the average population for the use case. Total benefit scores of the 320 scored use cases ranged from 4.8 to 8.3.

[35] See in particular the document "IOU Perspective on VGI Use-case Benefits and Costs" linked in Annex 1.

- Ease/risk of implementation was similarly scored on a relative scale of 1-5, from “very difficult and risky” to “very easy and not risky.” A low score for ease/risk of implementation was also intended to point to significant barriers that should garner policy-maker attention.

- In total, 320 use cases out of the 355 use cases that passed screening were scored with at least a partial benefit score.[36] There were also 660 individual text comments submitted with the numerical scoring. For example, some comments on the scoring pointed to why specific use cases received a high or low score for ease/risk of implementation. Scoring results and comments are available to view and download in the Use Case Assessment Database.[37]

Step (d) Ranking. The Working Group did not agree upon one specific ranking of the 320 use cases as to which would provide higher or lower value. However, participants also recognized that policy-making would be difficult if all 320 use cases were left undifferentiated, so the Working Group defined several “subsets” of use cases that might be considered “higher value” or “high scoring” or “priorities” or “favorable.” All of these subsets were assessed by the Working Group as having merit and useful for further work.

Results of Use Case Scoring

Figure 1 shows the distribution of benefit scores across all 240 LDV use cases. The figure shows both benefit metrics side-by-side for each use case – the scored “$/EV/year” metric (with use cases sorted from low to high) and the associated scored “EV Population” metric for each use case, for the population of EVs that could participate in that use case by 2022.[38]

The total benefit of a given use case is the product of these two benefit metrics. Figure 1 shows that many use cases with low $/EV/year scores have high population scores, so that the total benefit for these use cases can still be high. Conversely, many use cases with high $/EV/year benefit scores have low population scores, so the total benefit may be low.

It should also be noted that some use cases shown in Figure 1 may have higher benefits than shown by the maximum axis value of $800/EV/year; see “Scoring the Benefit Metric $/EV/year” on the next page.

[36] “Partial benefit score” means either a $/EV/year score or an EV Population score. The total of 320 scored use cases does not include a number of technology and vehicle-type variants of the same use case, see Annex 4 for details on the MHDV technology variants. There were 5 LDV technology variants and 83 MHDV technology variants also scored; these technology variants are included in the listing in Annex 5 and listed separately in the Use Case Assessment Database. In total in the database there are 437 use cases and technology variants of those use cases that passed screening.
[37] See Footnote 30.
[38] The data used in Figure 1 comes solely from the estimates made by Working Group participants in their scoring of the use cases (see Annex 4). Figure 1 does not reflect directly upon any external studies or analysis, although participants may have used external sources in making estimates, and if so, they were asked to document this in scoring comments.

Scoring the Benefit Metric $/EV/year

The benefit metric $/EV/year was scored according to five multiple-choice options for LDV use cases: $1-50, $50-150, $150-300, $300-600, and $600-1000 (see Annex 4). Ranges for MHDV scoring were a factor of ten higher, so the highest MHDV range was $6,000-10,000. When calculating the average score for a given use case based on scores submitted by participants, the mid-point of these ranges was used. Thus, the highest average score possible is $800/EV/year for an LDV use case, given the multiple-choice options available to scorers. Six LDV V2G use cases received this highest average score of $800/EV/year, as reflected in Figure 1. If scorers wanted to score a use case higher than the highest option, they were instructed to so indicate in their scoring comments. Comments for at least three LDV V2G use cases indicated that the benefit should be scored as high as $3000/EV/year for those use cases. For MHDV scoring, eight V1G and five V2G use cases were scored with the highest option of $8,000/EV/year, and comments indicated that scores should be higher than $10,000/EV/year for some of those.

There are some use cases with both high $/EV/year scores and high population scores, and these result in high total scored benefits:

- The highest total scored benefit from a single LDV use case is $200 million/year from Use Case #1, residential single-family home V1G with indirect control of charging, for customer bill management.
- The second highest total scored benefit is $160 million/year from Use Case #4, residential single-family home V1G with direct control of charging, for customer bill management.
- The third highest total benefit, also $160 million, is from Use Case #827, for commercial workplace V2G with direct control of charging, for customer bill management. However, V2G use case #827 has a low average score for ease/risk of implementation.
- There are a further 15 use cases that also have a low average score for ease/risk of implementation but that have a high total benefit ranging from $10 million to $100 million. To the extent that policy could remove barriers that would improve the ease/risk of implementation, these use cases might be targeted by policy as unlocking high value.[39]
- There are a further two use cases with total benefit above $100 million and high scores for ease/risk of implementation, for rideshare vehicle charging in single-family homes and public destination.[40]

Figure 2 shows the distribution of total benefit in dollars per year across all use cases, which is the product of the $/EV/year metric and the population metric. As can be seen, total benefits from LDV use cases are in general significantly higher than benefits from MHDV use cases according to the scoring by Working Group participants, due in part to higher assessed EV populations for LDV in the short-term. The highest total benefit among MHDV use cases was $16 million/year, for small truck fleet charging with either direct or indirect control, for customer bill management (Use Cases #2245 and #2248).

[39] These 15 use cases are the V1G use cases 498, 906, 918, 1026, 1110, 1121, 1230, 1334, 1434, 1442; and the V2G use cases 115, 118, 1028, 1436, 1544.

[40] These two use cases are 205 and 1226.

Figure 1: Distribution of Average Benefit Scores for LDV Use Cases
($/EV/year and EV Population)

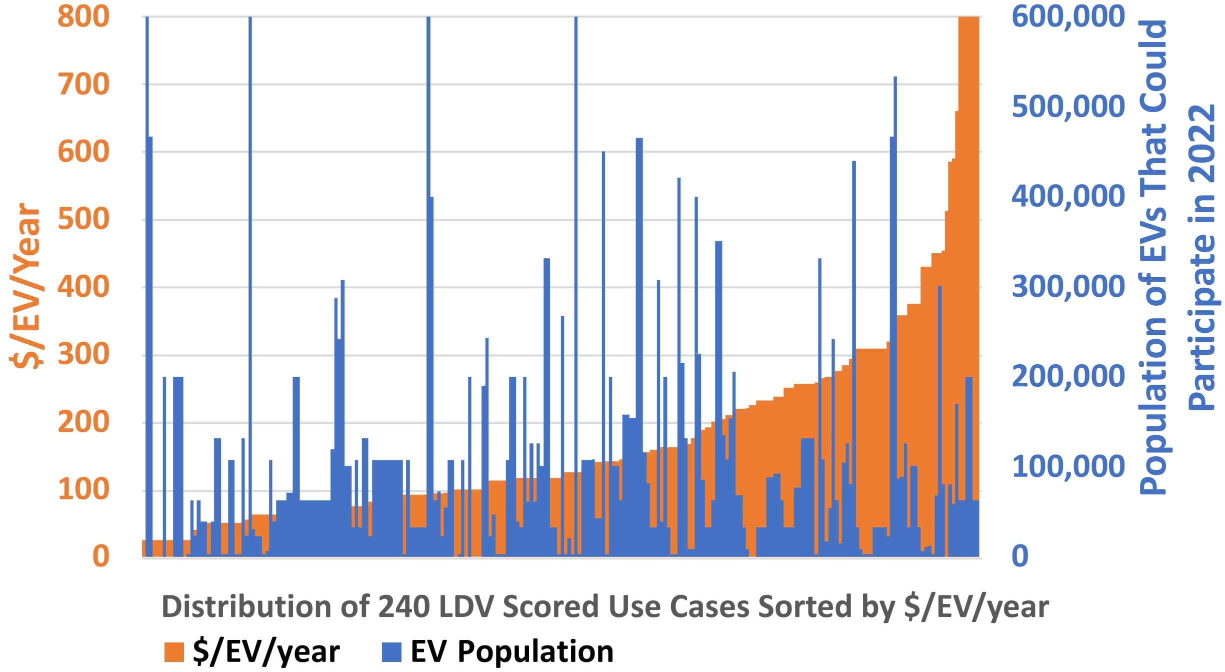
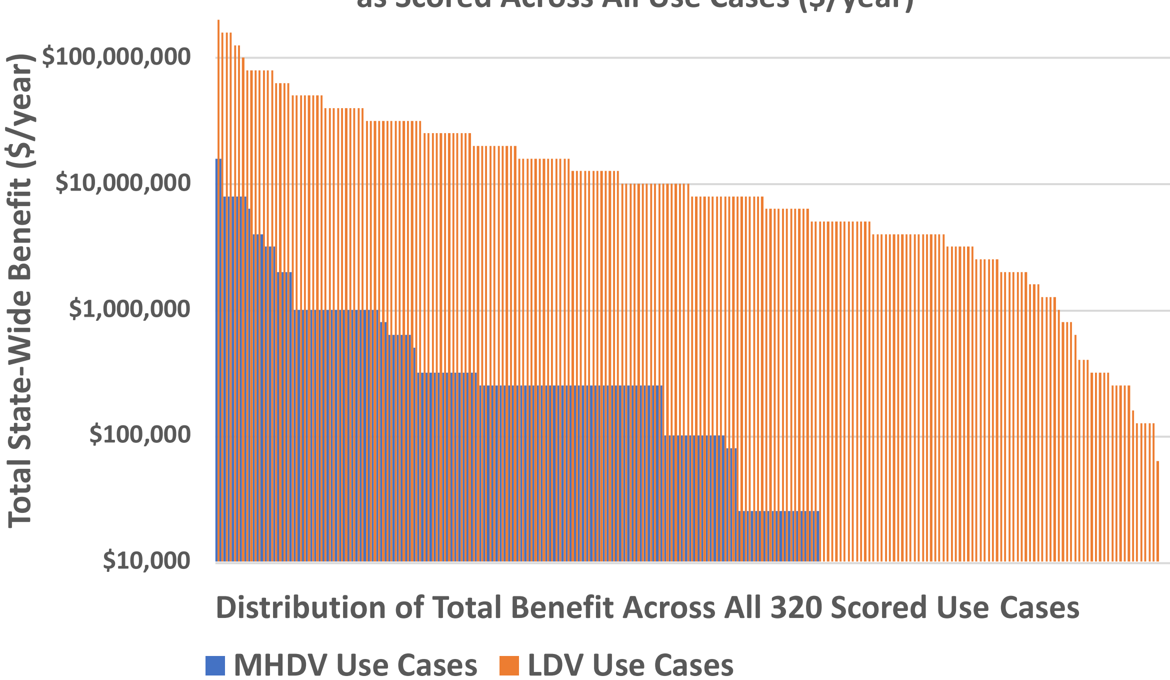


Figure 2: Distribution of Total State-Wide Benefit in 2022
as Scored Across All Use Cases ($/year)



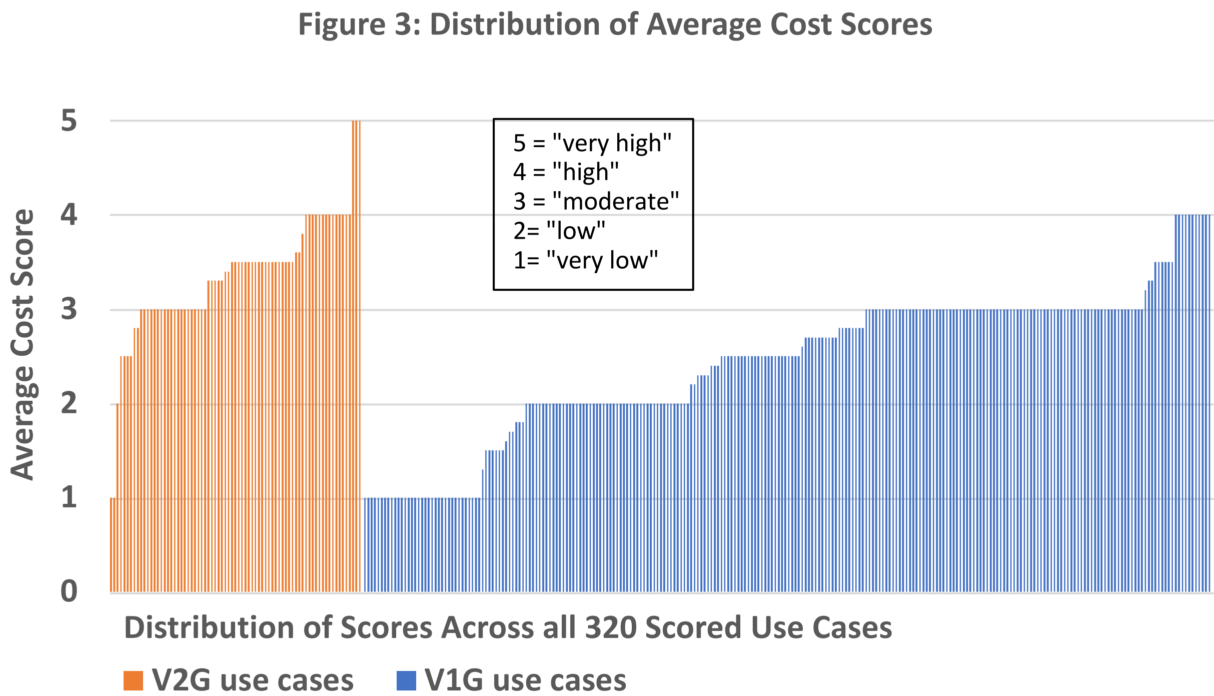


Figure 3: Distribution of Average Cost Scores
5 = "very high"
4 = "high"
3 = "moderate"
2= "low"
1= "very low"
Average Cost Score
5
4
3
2
1
0
Distribution of Scores Across all 320 Scored Use Cases
V2G use cases
V1G use cases

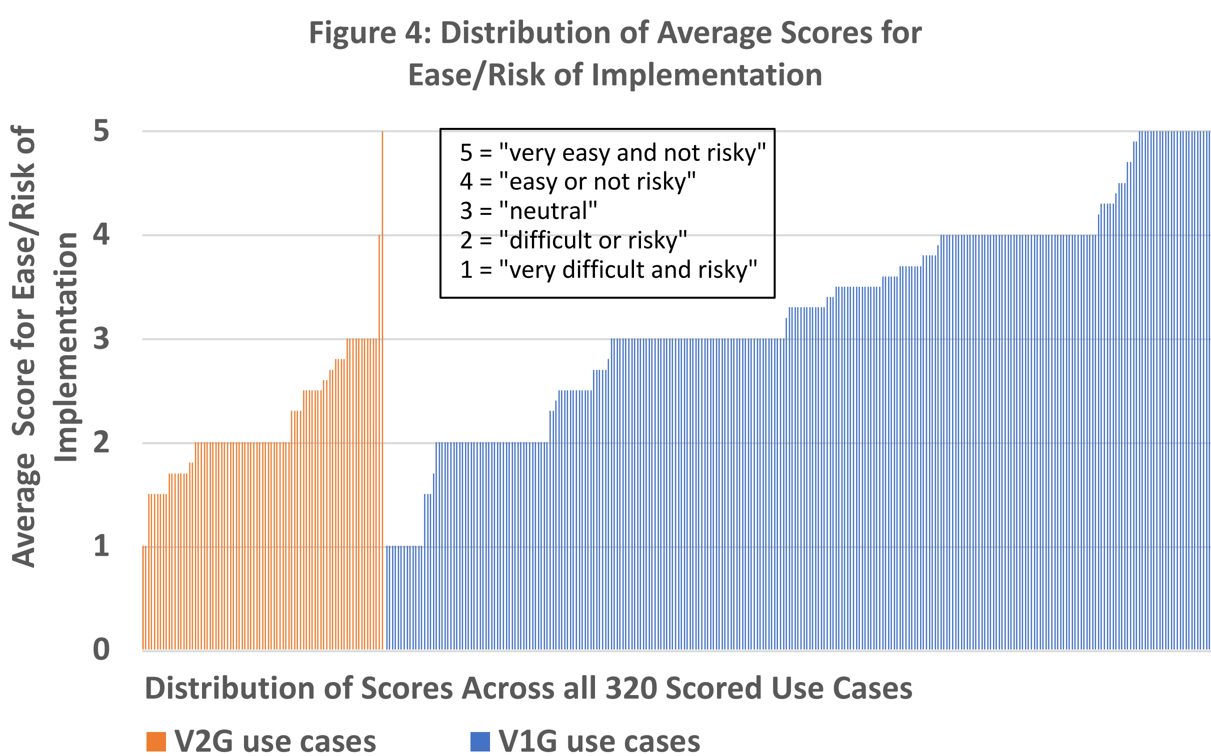


Figure 4: Distribution of Average Scores for Ease/Risk of Implementation
5 = "very easy and not risky"
4 = "easy or not risky"
3 = "neutral"
2 = "difficult or risky"
1 = "very difficult and risky"
Average Score for Ease/Risk of Implementation
5
4
3
2
1
0
Distribution of Scores Across all 320 Scored Use Cases
V2G use cases
V1G use cases

Working Group Answers to PUC Question (a)

The conclusion of the Working Group was that all use cases that passed screening and received at least a benefit score should, for the purposes of this report, be considered as "able to provide value now."[41] These 320 use cases are given in Annex 5. Most Working Group participants agreed that no scored use case should be excluded from being considered as "able to provide value now," since all use cases that passed screening and received a benefit score indicated at least some value.[42]

However, the value perceived by Working Group participants for these use cases varied widely on a broad spectrum, when benefits, costs, and the ease and riskiness of implementation (related to barriers and many other factors) are taken into account. For example, high-cost and low-benefit use cases should not be viewed the same as low-cost and high-benefit use cases. Therefore, it is clear that these 320 use cases should not all be treated equally in policy-making, but should be differentiated across a spectrum of value. Furthermore, many other use cases developed by the Working Group beyond these 320 use cases have the potential to provide value in the medium- and long-term.

Since the scoring of use case costs and the ease and risk of implementation was relative, meaning that costs could not be compared with benefits, the Working Group was unable to arrive at any quantitative assessment of "net value." Nevertheless, as noted above, during the ranking step of the use case assessment process, the Working Group solicited from participants and documented a number of suggested "subsets" of use cases that might be termed "higher value" or "high scoring" or "favorable," although no such terms were agreed upon by the Working Group. All of these subsets were assessed by at least some participants as having merit and useful for further work.

Highlighting or Ranking Use Case Value

Based on use case scoring, a number of "subsets" of smaller groups of use cases were developed by the Working Group for highlighting or ranking use case value, summarized below. These are provided as part of the Working Group's answer to PUC Question (a).

1. "Consensus use cases." Most Working Group participants agreed that priority sectors and applications for use cases providing value in the short-term include the following:[43]

- Residential sector broadly, for LDV use cases
- Commercial workplace sector broadly, for LDV use cases

[41] Use cases receiving at least a benefit score means that at least one participant scored the use case for benefits, either for the $/EV/year benefit metric, and/or for the metric total population of EVs that could participate by 2022. There was some debate about whether use cases scored on only one of these metrics be excluded, since the full benefit result of multiplying the two metrics together could not be obtained, most participants agreed to include the use case if only one of these metrics was scored.

[42] The conclusion that all use cases with benefits should, for the purposes of this report, be considered as "able provide value now" should only be interpreted as an answer to PUC Question (a), and does not imply that programs to enable these use cases necessarily maximize benefits and minimize costs.

[43] The Working Group agreed to call these "consensus use cases" even though a few participants were not in full agreement with this term or with every aspect of the subset definition. PUC Question (a) uses the word "now" and as noted previously, the Working Group interpreted "now" to mean the short-term through 2022.

- Customer bill management
- Distribution upgrade deferrals
- Home and building backup power (V2H and V2B)
- Commercial sector demand-charge management (customer bill management)
- V2G that can provide value now, including V2G use cases in the bullets above
- System applications easily implementable for vehicle locations with daytime charging ability
- Vehicle types with excess battery capacity relative to duty cycle, such as school buses
- All system and customer applications that defer charging away from peak periods

2. Honda value-metric subset. Honda defined a "value metric" that integrated all three metrics of benefits, costs, and ease/risk of implementation, as a simple way to rank the scored use cases considering all three metrics. This metric gives a means to focus on a set of high-value use cases for more in-depth analysis. The metric Honda developed was the simple multiplication of the benefit score times the cost score (inverted so lowest cost gives the highest score) times the score for ease/risk of implementation. This three-item product gives a single value that can be ranked. Honda also pointed to the text comments that participants made while scoring the use cases, and suggested that comments for the high-value use cases identified through this metric be examined in depth, as to commonalities, context, trends, and drivers for specific use cases based on existing policies and programs.

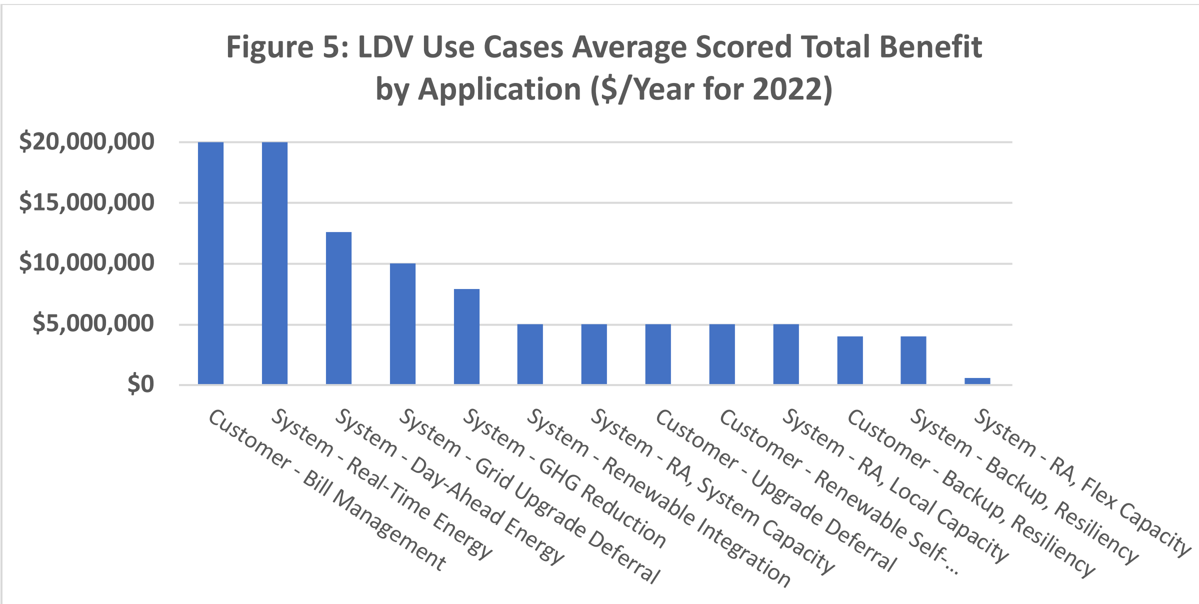
3. Ford high-value subset. Ford suggested filtering for high-value LDV use cases that provide at least $150 in value per EV per year, and that received a score for ease/risk of implementation of either "very easy and not risky" (score of 5 on scale of 1-5) or "easy or not risky" (score of 4). Ford suggested that after such filtering, each of the high-value use cases should be reviewed to brainstorm the policy and industry actions required to catalyze implementation and capture that value.

4. Gridworks above-median subset. This subset defines a use case as providing higher value if all three metrics for a given use case -- benefits, costs, and ease/risk of implementation -- were each scored above the median value of all use cases scored for that metric. Separate medians were employed for LDV vs. MHDV use cases. "Above median" is a standard method of distinguishing "high" from "low" in any groupings, and Gridworks as the Working Group facilitator applied this standard method to compare against the other subsets.

5. Karim Farhat Prime Flex subset. This subset defines a fully scored use case as "favorable" if at least one party deemed it as such. By design, the methodology did not rely on scoring averages, in order to be as inclusive as possible. The threshold for defining a use case as "favorable" is: a minimum total state-wide benefit of at least $100,000 per year from the estimated EV population that could participate by 2022; a cost score of "low" or "very low"; and an ease/risk of implementation score of either "very easy and not risky" or "easy or not risky" (for further details see material linked in Annex 1).

6. Nissan analysis by application and sector. Nissan analyzed average benefit scores by application, to organize the screening results of the 17 defined use case applications with the highest benefit scores. See the Nissan document linked in Annex 1 for details. The highest LDV scores were for customer bill management, system real-time energy, system day-ahead energy, and system grid upgrade deferral applications. The highest MHDV scores were for customer bill management, customer renewable self-consumption, system RA (system capacity), system day-ahead energy, and customer backup/resiliency applications. Nissan also analyzed average benefit scores by sector. The highest scoring sectors were residential single-family home, residential single-family-home rideshare, commercial public commute, and commercial workplace.

Figure 5 shows the Nissan analysis applied to LDV use cases by application. The "average scored benefit" is the product of the $/vehicle/year benefit metric and the "population" benefit metric for each use case, and then averaged across all use cases for that application. The "population" benefit metric for each use case is the scored level of EV population for that use case that could technically participate in VGI programs by 2022, not considering program participation levels (see description of scoring above).



Any one of the subsets defined above could be chosen and analyzed, in terms of value of the use cases and detailed understanding of benefits, costs, and ease/risk of implementation. The text comments provided with scoring submissions provide a further pool of insight on the use cases within these subsets. Designations of which use cases fall into which subsets are contained in the Use Case Assessment Database.[44]

Insights from Use Case Subsets

There are 29 LDV use cases that simultaneously appear in all of the defined subsets above. This means these use cases are scored highly in a robust manner—they score highly across a number of different metrics simultaneously. All of these use cases are V1G, as no V2G use cases were highly scored enough to appear in all subsets. This is generally because, while many V2G use cases were scored highly for total benefits, they were often scored as having higher costs and less ease or higher risk of implementation. Figures 6 and 7 show the sectors and applications associated with these 29 use cases.[45]

[44] See Footnote 30. All use case material is also available as a series of Excel files linked in Annex 1.

[45] Rideshare vehicle charging in Figure 6 is distributed across a number of different residential and commercial sectors.

Figure 6: Sectors of LDV Use Cases Appearing in All Subsets

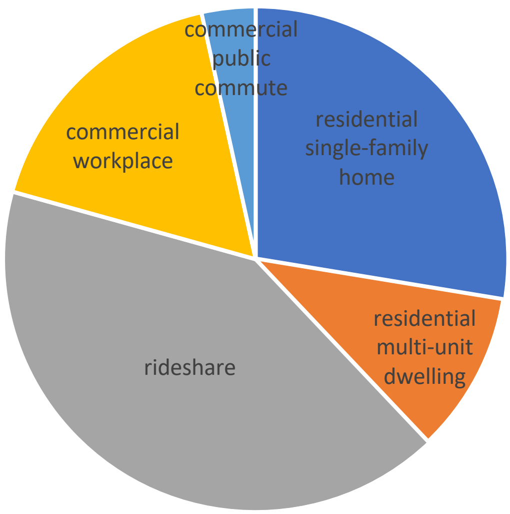
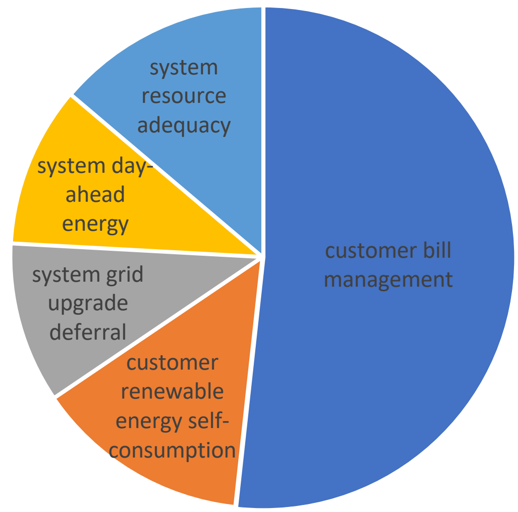


Figure 7: Applications of LDV Use Cases Appearing in All Subsets



Insight from a Particular Subset and Definition of Value

To illustrate the insight that can be gained from looking through the lens of a particular subset using a particular definition of value, Tables 3 and 4 show the top-25 ranked LDV and MHDV use cases according to the Honda value metric. Again, all are V1G use cases for reasons noted above. It can be seen that:

- The majority of LDV use cases are for residential single-family homes, with five use cases for commercial workplace, four use cases for residential multi-unit dwellings, and three use cases for commercial public commute (i.e., public parking).
- The majority of MHDV use cases are for small trucks, with an additional four use cases for large trucks, six use cases for transit buses, and two use cases for school buses.
- LDV customer applications are for bill management and grid upgrade deferral across all sectors, and for renewable self-consumption in both residential and commercial workplace use cases.
- Customer bill management is the main application for large and small trucks and school buses.
- Small truck use cases provide the greatest number of different applications -- customer bill management, customer renewable energy self-consumption, system renewable energy integration, system day-ahead energy, and system GHG reduction.
- There are six rideshare vehicle charging use cases, for charging both in residential single-family homes and multi-unit dwellings, and for the commercial public commute sector (i.e., charging in public parking).
- Commercial workplace bill management and renewable self-consumption are both unified and fragmented, meaning scoring deemed both options to be high-value – charging infrastructure operated by the workplace entity, and charging operated by a third party or aggregator.

Table 3. Top-25 Ranked LDV Use Cases According to Honda Value-Metric

ID	Sector**	Application	Approach	Resource*
1	Residential - Single Family Home	Customer - Bill Management	Indirect	Unified
13	Residential - Single Family Home	Customer - Upgrade Deferral	Indirect	Unified
16	Residential - Single Family Home	Customer - Upgrade Deferral	Direct	Unified
37	Residential - Single Family Home	Customer-Renewable Self-Consumption	Indirect	Unified
49	Residential - Single Family Home	System - Grid Upgrade Deferral	Indirect	Unified
109	Residential - Single Family Home	System - Renewable Integration	Indirect	Unified
121	Residential - Single Family Home	System - GHG Reduction	Indirect	Unified
133	Residential - Single Family Home	System - RA, System Capacity	Indirect	Unified
148	Residential - Single Family Home	System - RA, Flex Capacity	Direct	Unified
160	Residential - Single Family Home	System - RA, Local Capacity	Direct	Unified
205	Residential - Single Family Home, Rideshare	Customer - Bill Management	Indirect	Unified
241	Residential - Single Family Home, Rideshare	Customer-Renewable Self-Consumption	Indirect	Unified
313	Residential - Single Family Home, Rideshare	System - Renewable Integration	Indirect	Unified
337	Residential - Single Family Home, Rideshare	System - RA, System Capacity	Indirect	Unified
410	Residential - Multi-Unit Dwelling	Customer - Bill Management	Indirect	Fragmented
458	Residential - Multi-Unit Dwelling	System - Grid Upgrade Deferral	Indirect	Fragmented
518	Residential - Multi-Unit Dwelling	System - Renewable Integration	Indirect	Fragmented
614	Residential - Multi-Unit Dwelling, Rideshare	Customer - Bill Management	Indirect	Fragmented
817	Commercial - Workplace	Customer - Bill Management	Indirect	Unified
818	Commercial - Workplace	Customer - Bill Management	Indirect	Fragmented
830	Commercial - Workplace	Customer - Upgrade Deferral	Indirect	Fragmented
853	Commercial - Workplace	Customer-Renewable Self-Consumption	Indirect	Unified
854	Commercial - Workplace	Customer-Renewable Self-Consumption	Indirect	Fragmented
866	Commercial - Workplace	System - Grid Upgrade Deferral	Indirect	Fragmented
1753	Commercial - Public Commute, Rideshare	System - GHG Reduction	Indirect	Unified
1430	Commercial - Public Commute	Customer - Bill Management	Indirect	Fragmented
1514	Commercial - Public Commute	System - Day-Ahead Energy	Indirect	Fragmented

(*) Resource is “aligned” for all entries

Table 4. Top-25 Ranked MHDV Use Cases According to Honda Value-Metric

ID	Sector	Application	Type	Resource*	Vehicle Type**
1837.2	Commercial-Fleet, Transit Bus	Customer - Bill Management	Indirect	Unified	LR Transit Bus A
1837.3	Commercial-Fleet, Transit Bus	Customer - Bill Management	Indirect	Unified	LR Transit Bus B
1838.2	Commercial-Fleet, Transit Bus	Customer - Bill Management	Indirect	Fragmented	LR Transit Bus A
1921.2	Commercial-Fleet, Transit Bus	System - Day-Ahead Energy	Indirect	Unified	LR Transit Bus A
1921.3	Commercial-Fleet, Transit Bus	System - Day-Ahead Energy	Indirect	Unified	SR Transit Bus B
1969.2	Commercial-Fleet, Transit Bus	System - RA, System Capacity	Indirect	Unified	LR Transit Bus A
2041	Commercial-Fleet, School Bus	Customer - Bill Management	Indirect	Unified	
2042	Commercial-Fleet, School Bus	Customer - Bill Management	Indirect	Fragmented	
2245	Commercial-Fleet, Small Truck	Customer - Bill Management	Indirect	Unified	
2245.1	Commercial-Fleet, Small Truck	Customer - Bill Management	Indirect	Unified	Small Truck B
2246	Commercial-Fleet, Small Truck	Customer - Bill Management	Indirect	Fragmented	
2246.1	Commercial-Fleet, Small Truck	Customer - Bill Management	Indirect	Fragmented	Small Truck B
2248.1	Commercial-Fleet, Small Truck	Customer - Bill Management	Direct	Unified	Small Truck B
2281	Commercial-Fleet, Small Truck	Customer-RE Self-Consumption	Indirect	Unified	Small Truck B
2284	Commercial-Fleet, Small Truck	Customer-RE Self-Consumption	Direct	Unified	Small Truck B
2329.1	Commercial-Fleet, Small Truck	System - Day-Ahead Energy	Indirect	Unified	Small Truck B
2353	Commercial-Fleet, Small Truck	System - Renewable Integration	Indirect	Unified	Small Truck B
2354	Commercial-Fleet, Small Truck	System - Renewable Integration	Indirect	Fragmented	Small Truck B
2356	Commercial-Fleet, Small Truck	System - Renewable Integration	Direct	Unified	Small Truck B
2365	Commercial-Fleet, Small Truck	System - GHG Reduction	Indirect	Unified	Small Truck B
2368	Commercial-Fleet, Small Truck	System - GHG Reduction	Direct	Unified	Small Truck B
2449.1	Commercial-Fleet, Large Truck	Customer - Bill Management	Indirect	Unified	Large Truck A
2450.1	Commercial-Fleet, Large Truck	Customer - Bill Management	Indirect	Fragmented	Large Truck A
2452.1	Commercial-Fleet, Large Truck	Customer - Bill Management	Direct	Unified	Large Truck A
2458.1	Commercial-Fleet, Large Truck	Customer - Bill Management	Direct	Unified	Large Truck A

(*) Resource is “aligned” for all entries. (**) For details on vehicle types, see Annex 3. LR = long range, SR = short range.

V2G Use Cases

There are 80 V2G use cases among the 320 scored use cases. Figures 8 and 9 show the distribution of sectors and applications for these V2G use cases. As stated previously, many of these V2G use cases are scored highly for benefits, but most are scored as having higher costs and/or less ease or higher risk of implementation, thus they do not appear in the defined subsets. Among these 80 V2G use cases are 7 that appear in at least one of the subsets, for residential single-family homes and commercial workplaces and for backup/resiliency, bill management, and renewable self-consumption (Table 5).

Figure 8: Sectors of All V2G Use Cases

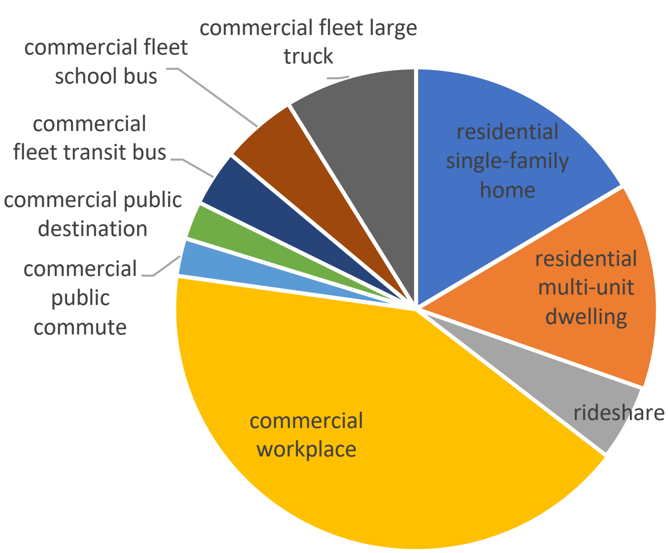


Figure 9: Applications of All V2G Use Cases

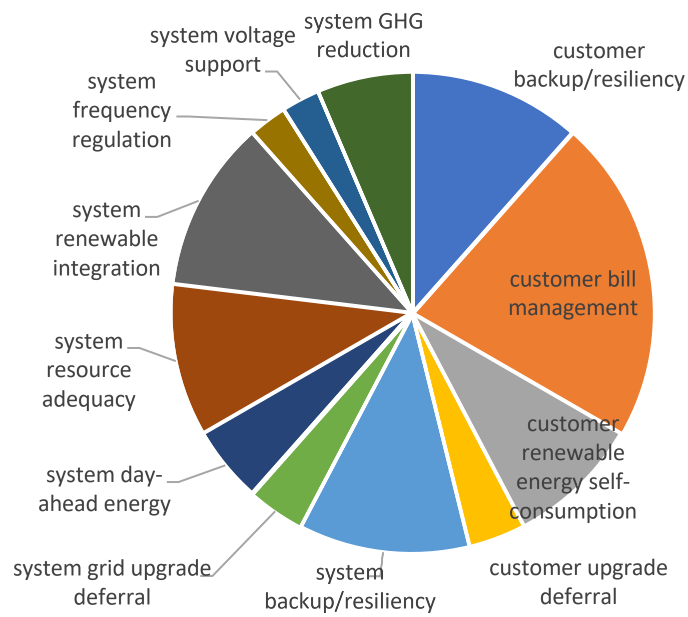


Table 5. V2G Use Cases Appearing in High-Scoring Subsets

ID	Sector	Application	Type	Resource*
31	Residential - Single Family Home	Customer - Backup, Resiliency	Indirect	Unified
34	Residential - Single Family Home	Customer - Backup, Resiliency	Direct	Unified
826	Commercial - Workplace	Customer - Bill Management	Direct	Unified
850	Commercial - Workplace	Customer - Backup, Resiliency	Direct	Unified
860	Commercial - Workplace	Customer-Renewable Self-Consumption	Indirect	Fragmented
872	Commercial - Workplace	System - Grid Upgrade Deferral	Indirect	Fragmented
2458	Commercial - Fleet, Large Truck (class 6-8)	Customer - Bill Management	Direct	Unified

(*) Resource is “aligned” for all entries

Towards Further Development of Use Case Understanding

The summaries and insights provided in this section are but a slice of the total insights possible–the Working Group generated a wealth of information on over 1,000 VGI use cases. The use cases that were screened out from this initial set of 1,000 could still provide value in the future, and text comments on screening and further documented screening insights generated by the screening teams can help further distinguish high-value use cases beyond the short-term (see Annex 1 for links to all this material). Of the 320 use cases that received scores for benefits, costs, and/or ease/risk of implementation, many can be ranked or prioritized in different ways to give particular perspectives on value, also considering the 660 individual comments generated by participants while scoring use cases.

As noted above, there are many use cases with low $/EV/year benefit scores but high population scores, so that the total benefit for these use cases can still be high. And conversely, many use cases with high $/EV/year benefit scores have low population scores, so the total benefit may be low. There are also use cases with both high $/EV/year scores and high population scores, and these result in highly scored total statewide benefits. The highest total benefit from a single LDV use case is $200 million/year, and from an MHDV use case is $16 million/year.

The good news is that there are many potential VGI use cases which can provide value. And the potential market for VGI is diverse, complex and interwoven across a broad swath of the power and transportation sectors. Given the use case assessment work performed by the Working Group, it appears that the work of developing VGI markets will demand persistent experimentation for the next several years, rather than simple broad, sweeping strokes that can happen quickly. Importantly, leaders from both the demand and supply sides of the nascent VGI market agree California should take an inclusive approach to potential VGI opportunities.

SECTION B. PUC QUESTION (B) WHAT POLICIES NEED TO BE CHANGED OR ADOPTED TO ALLOW ADDITIONAL USE CASES TO BE DEPLOYED IN THE FUTURE?

The Working Group developed a set of 92 individual recommendations for policy actions that California state agencies, utilities, CCAs, other LSEs, and the California ISO could undertake to advance VGI in the short-, medium-, and long-term.[46] The full text of all 92 recommendations is given in Annex 6. These recommendations are separated into 11 different policy categories (Table 6).

Table 6. Policy Categories

#	Category
1	Reform retail rates
2	Develop and fund government and LSE customer programs, incentives, and DER procurements
3	Design wholesale market rules and access
4	Understand and transform VGI markets by funding and launching data programs, studies and task forces
5	Accelerate use of EVs for bi-directional non-grid-export power and PSPS resiliency and backup
6	Develop EV bi-directional grid-export power including interconnection rules
7	Fund and launch demonstrations and other activities to accelerate and validate commercialization
8	Develop, approve, and support adoption of technical standards not related to interconnection
9	Fund and launch market education & coordination
10	Enhance coordination and consistency between agencies and state goals
11	Conduct other non-VGI-specific programs and activities to increase EV adoption

Together, these categories address virtually all aspects of policy support for the VGI use cases providing value in the short-term, as well as many use cases which could potentially provide value in the medium- and long-term:

- Category 1, reforming retail rates, can support both "indirect" use cases, for which charging decisions can be based on time-varying price signals (such as TOU rates), and "direct" use cases where new rates can improve cost-effectiveness or provide new incentives for managed charging.
- Category 2, public and ratepayer funds for government and LSE customer programs, incentives, and procurements can support scale-up and cost reduction of already-commercial VGI solutions for most V1G use cases, as well as already-commercial V2G use cases.
- Category 3, recommendations addressing wholesale market rules and access can support use cases for system applications, including a wide variety of grid services, from day-ahead and real-time energy to resource adequacy, renewable energy integration, and grid upgrade deferrals.
- Category 4, further information on customer engagement, costs, benefits, and scale, can support market-based knowledge and information for reducing costs and removing barriers of use cases that may be under-employed currently but promise high value if market barriers are removed.

[46] All details and information about the policy recommendations are contained in the Policy Recommendations Database, available online at https://airtable.com/shr9JBvC2bAofuJpj. Database tables can be viewed and downloaded from that link and Excel versions are also available directly via the links in Annex 1.

- Category 5, on power generation not exported to the grid, can support behind-the-meter V2B and V2H use cases for customer backup and resiliency, including resiliency to counteract Public Safety Power Shutoffs (PSPS).
- Category 6, on power generation exported to the grid, can support grid-facing V2G use cases, such as system renewable energy integration, system resource adequacy, and system ancillary services like frequency regulation.
- Category 7, on public funding of demonstrations and commercialization activities, can support enhanced knowledge and market development for VGI solutions that are in the process of being fully commercialized.
- Categories 8-11 can support a wide variety of other programs and activities that can contribute to market development, technical standards, and coordination to address VGI in an integrated manner across state agencies.

Policy Recommendations Classification (Degree of Agreement) Based on Survey Results

To gain further insight into the policy recommendations and to classify the recommendations by degree of agreement from participants, the Working Group conducted a survey of participants and asked them four questions about each of the 92 recommendations (see Annex 2 for survey details):[47]

Policy Survey Questions

1. Do you agree or disagree that this recommendation will advance VGI in California?
2. How clear, understandable, and policy ready is this recommendation?
3. How critical and relevant is this policy to meeting your organization's own VGI objectives?
4. Any other comments on this recommendation?

The possible responses to Question #1 on whether respondents agree with a given recommendation were "strongly agree", "agree", "neutral", "disagree", and "strongly disagree." The Working Group utilized these responses to classify the policy recommendations into "strongest agreement," "good agreement," "majority neutral," and "majority disagree."[48] Table 7 gives the criteria for all classifications and the number of recommendations so classified. Medium- and long-term recommendations were put into a separate classification to allow a sharper focus on the short-term, given the large number of short-term recommendations.

Tables 8-13 in the following sub-sections list the policy recommendations within each of these classifications. The divergence or convergence of survey responses, that is, the degree to which

[47] This survey was conducted on an expedited basis and not all policy recommendations were clear at the time. Survey responses remain anonymous and do not constitute formal institutional comment on policy proposals.
[48] The Working Group did not use the results of Questions #2 or #3 in assessing recommendations, but full survey results are available for further analysis; see Annex 1 for links to this material. Annex 8 lists the roughly 1200 comments received in response to Question #4 and Annex 9 shows graphically the scores for Questions #1 to #3.

respondents agreed with each other in rating a policy, is also noted in the following sub-sections, as either "strong convergence," "broad convergence," or "divergence of responses."[49]

Table 7. Classification of Policy Recommendations

Count	Classification	Criteria for Classification
23	Strongest agreement	Agree or strongly agree > 66% and strongly disagree < 20%
15	Good agreement	Agreement > disagreement and agreement > neutral
16	Majority neutral	Neutral > 50% [50]
7	Majority disagree	Disagreement > 50%
16	Policy action already underway	CPUC Energy Division staff comments so indicates
15	Medium-term and long-term	Policy recommendation timeframe so indicates
92	Total	

It must be noted that the classification for about one-fifth of the policy recommendations in this section may be less valid than for the others because the recommendations were re-worded by the original submitters after the survey was taken. Survey results on these re-worded recommendations may not as accurately reflect agreement with the current wording compared to recommendations whose wording remained unchanged. There was no time to re-conduct the survey and the Working Group, as it was concluding, believed it was in the best interest of clear policy-making to allow the re-wording. [51]

Digging Deeper: Participant Comments on Policy Recommendations from the Survey

There were over 1200 detailed comments on the policy recommendations, provided by 28 respondents in response to a survey of the whole Working Group. Annex 8 provides all of the survey comments. In addition, comments by some participants on recommendations made after the survey are also available as part of the Working Group materials; see Annex 1. ***Together all of these comments provide a wealth of further insight into the recommendations and can be utilized by agency staff and others to help further understand and consider policy actions.***

[49] For purposes of this section, "strong convergence" was defined as a mathematical standard deviation of less than 0.6 across all Question #1 survey responses to a given policy recommendation, "broad convergence" was defined as standard deviation between 0.6 and 1.0, and "divergence of responses" as greater than 1.0.

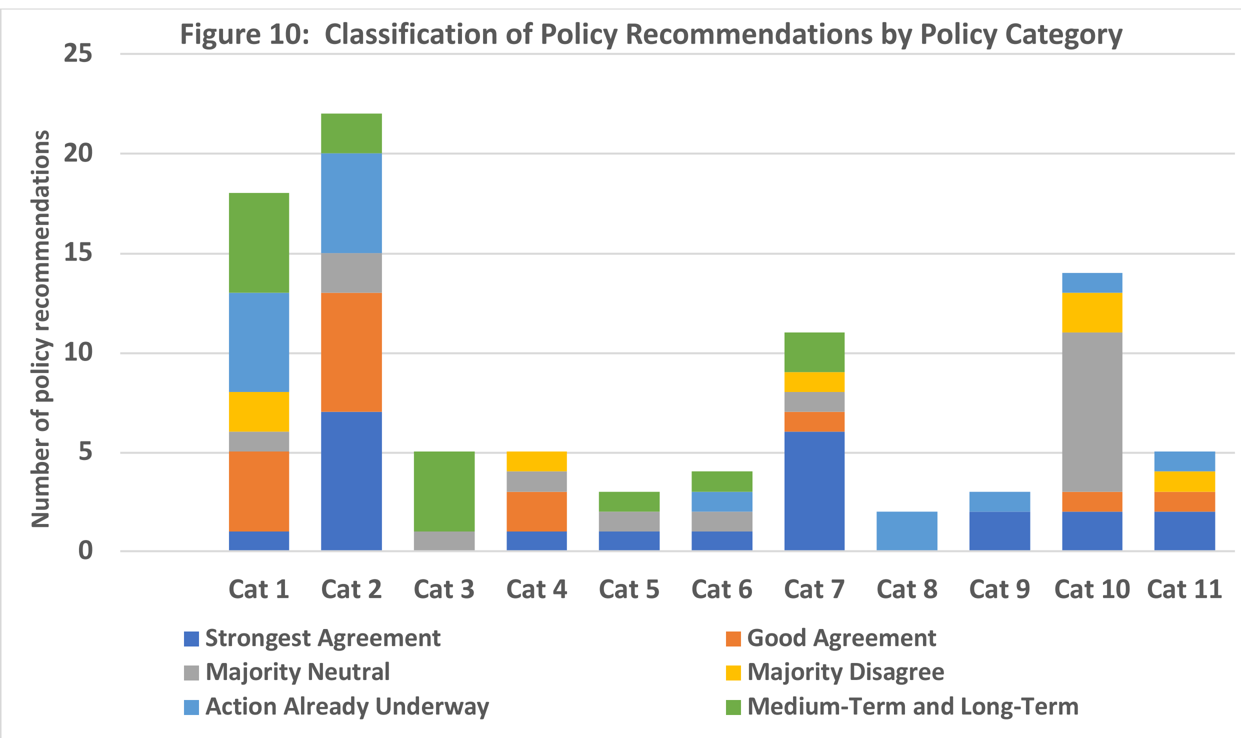
[50] "Majority neutral" also includes five cases where neutral is not an absolute majority, but rather total neutral responses are both greater than total disagreement response and greater than total agreement responses (1.06, 1.17, 3.01, 4.04, 7.01). These cases are noted in the text as also having a higher divergence of responses.

[51] There were 19 recommendations re-worded by the original submitters after the survey was taken: 1.10, 1.12, 1.16, 1.17, 2.02, 2.12, 2.16, 2.19, 2.20, 2.23, 4.03, 4.06, 6.01, 7.09, 7.11, 10.01, 10.04, 10.05, and 10.09. Re-wording was done mainly for clarification, so the policy substance of new wordings may remain similar to original wordings. The original wording of these 19 recommendations, upon which the survey results were based, is provided for reference in the Policy Recommendations Database linked in Annex 1. Most participants deemed that it was better to serve the needs of state agencies by accepting the updated wording at the risk of invalidating some of the survey results, recognizing that there was no time to repeat the survey for these recommendations. The classification of the 19 re-worded recommendations in this section is based on survey results for the original wording at the time of the survey.

Policy Recommendations Classifications by Category

The number of policy recommendations within each policy category and the classification of those recommendations are shown in Figure 10. Some characteristics of each category:

- More than half of Category 1 recommendations point to retail rate actions already underway or that should be further considered for the medium- and long-term. Rate applications not already in progress would be medium-term to allow time for submission, public review, and implementation.
- Most Category 2 recommendations on programs, procurements, and incentives had strong or good agreement, with a number also related to action already underway.
- Three-quarters of Category 3 recommendations on wholesale markets relate to the medium-term.
- Recommendations in Category 4 on studies and data have mostly good to neutral agreement.
- Although both Category 5 (bidirectional non-export/V2B) and Category 9 (market education) had fewer recommendations than other categories, they also received some of the strongest agreement.
- Category 7 on demonstrations and pilots has the highest share of strongest-agreement recommendations of any category.
- All Category 8 recommendations on technical standards relate to policy action already underway.
- More than half of the recommendations in Category 10 on inter-agency coordination are classified as majority-neutral, meaning most survey respondents were neutral on the relevance of these recommendations for scaling VGI.
- Category 11 on other programs and activities had mostly strong or good agreement.



Short-Term Recommendations with Strongest Agreement

There are 23 short-term recommendations with the strongest agreement (Table 8).[52]

Table 8. Short-Term Policy Recommendations with Strongest Agreement

Rec #	Policy Recommendation
1.07	Create an "EV fleet" commercial rate that allows commercial and industrial customers to switch from a monthly demand charge to a more dynamic rate structure
2.01	Require utilities to broadcast signals to a DER marketplace of qualified vendors (curtailment and load)
2.02	V2G systems become eligible for some form of SGIP incentives
2.04	Enable customers to elect BTM load balancing option to avoid primary or secondary upgrades, either if residential R15/16 exemption goes away, or as an option for non-residential customers
2.08	Consider coordinated utility and CCA incentives for EVs, solar PV, inverters, battery storage, capacity, and EV charging infrastructure to support resilience efforts in communities impacted by PSPS events
2.12	Allow V1G and V2G to qualify for SGIP to level the playing field with incentives for other DERs, but V1G would get less incentive compared to V2G based on permanent load shift logic
2.15	Incentive(s) for construction projects with coincident grid interconnection and EV infrastructure upgrade
2.17	Enable customers, via Rules 15/16 or any new EV tariff, to employ load management technologies to avoid distribution upgrades, and focus capacity assessments on the Point of Common Coupling
4.06	Use EPIC, ratepayer, US DOE, and/or utility LCFS funds for an on-going, multi-year program to convene VGI data experts to study lessons learned, quantify VGI/DER net value, fund new data sources, and study other topics
5.02	Pilot funding for EV backup power to customers not on microgrids, including goals for pilots in 2021-2022; utilities to consider feasibility of EVs for emergency backup in PSPS plans and resiliency solutions
6.07	Pilot funding for EV backup power to customers not on microgrids, including state-wide goals for at least 100 EVs by 2021 and 500 EVs by 2022; utilities to consider the feasibility of EVs for emergency backup generation in PSPS plans and resiliency solutions
7.03	Focusing on resiliency and backup application in workplace and multi-unit dwellings, leverage EPIC funding to pilot use-cases to understand and reduce costs and to streamline ease of implementation
7.04	Create pilots to demonstrate V2G's ability to provide the same energy storage services as stationary systems and let V2G systems participate in pilots for stationary storage
7.05	Special programs and pilots for municipal fleets to pilot V2G as mobile resiliency
7.07	Demonstration to define the means to allow aggregators, EV network providers, and charge station operators to dynamically map the capacity and availability of EVSE resources, using open standards
7.09	Use EPIC, ratepayer, USDOE, and/or utility LCFS funds ($50M) in many competitively bid large-scale demonstrations of promising VGI use cases to provide data needed to scale up VGI efforts (e.g., validate consumer acceptance, incentive levels, security, net value, and communication pathways)
7.11	Study to understand the impact on the distribution grid and generation system from EVs based on over ten existing or planned mandates from CARB and AQMDs to meet California’s 2045 carbon neutral goal
9.01	Optimize CALGreen codes for VGI and revise to require more PEV-ready parking spaces and expand to existing buildings.
9.02	Create public awareness and education programs and materials on V2G systems and how to get them. This could particularly be focused toward government fleets
10.04	State agencies coordinate and maintain consistency on TE and VGI across the different policy forums with no duplication of regulation, clear roles and vision on VGI and priority on state TE goals over VGI
10.09	Incentivize use of multiple open standards for VGI communication, charging networks, cloud aggregators, and site hosts
11.03	Streamline permitting for charging infrastructure
11.05	Create Incentives for charging infrastructure for new public parking lot construction projects

[52] Tables 8-13 contain shortened text versions of the “policy action” associated with each policy recommendation. The full-text versions of all 92 policy recommendations, providing the full scope of the recommendation, along with a list of the extensive additional information available for each policy recommendation, are given in Annex 6.

Of these 23 short-term recommendations with strongest agreement, virtually all had broad "convergence" among all policy survey respondents. Such convergence means that all respondents agreed with each other – that there was a high degree of consistency among the responses. Recommendations 2.08 on coordinated incentives, 7.05 on municipal fleet pilots, and 9.02 on public awareness had particularly strong convergence. The exceptions to this pattern were 2.12 on V1G and V2G qualifying for SGIP and 7.11 on grid impact studies, which had weaker convergence than the others. For 2.12, four respondents strongly disagreed with the recommendation. Policy makers and any future working groups should examine the recommendations and comments to better understand the sources of the divergence.

While there was strong agreement for all of these recommendations, survey comments also pointed to considerations and questions that might need to be addressed, for example:

- Some policies might be considered medium-term rather than short-term, such as 2.01 on signaling a DER marketplace, 2.02 on SGIP incentives, 6.07 on pilots for microgrid-related solutions, and 7.07 on mapping EVSE resources.
- One comment also questioned how 2.01 on signaling a DER marketplace differs from existing DR programs.
- Mapping of EVSE resources is already part of the job and business models of aggregators (7.07).
- The perceived need for behind-the-meter load balancing varied widely (2.04)
- Some questioned whether it was appropriate to extend SGIP to VGI (2.02 and 2.12).
- Leveraging EPIC funding (7.03) will require collaboration between CPUC and CEC.
- Studies to understand grid impacts of TE are already underway (7.11).
- Open standards are possibly out-of-scope for the VGI Working Group to recommend (10.09).
- Public awareness (9.02) should be expanded beyond just V2G to also include V1G and the benefits of electrification in general, and should not be a stand-alone policy but part of a larger outreach, vehicle replacement and infrastructure planning effort.
- Permit streamlining (11.03) received the highest agreement level of all recommendations across all policy categories. However, some commenters were not clear about potential CPUC roles and what could be done. Energy Division staff noted that the Draft TEF (Section 10.3), identifies one possible answer—that utilities could potentially also provide training to support other types of PEV readiness activities beyond building code adoption and implementation, such as permit streamlining.

Policy Action for Medium- and Heavy-Duty Vehicles

The Working Group discussed what makes medium- and heavy-duty vehicles (MHDVs) distinct from light-duty vehicles (LDVs) in terms of VGI use cases and policy actions. While MHDV use cases were assessed distinctly from LDV use cases in answering PUC Question (a), some participants suggested that MHDVs are something of an "overlay" for policy rather than a distinct category of policy action. Policies for LDVs can also apply to MHDVs, including commercial rates, interconnection, and aggregation. However, the differences between MHDVs and LDVs also need to be understood by policy-makers, including a smaller number of customers with higher loads, rigid duty cycles, the special potential of school and commuter buses because of their duty cycle, clustering of large loads for MHDV charging, and the need to upgrade distribution system capacity to accommodate and accelerate MHDV charging. Some policy recommendations directly mention MHDVs, notably for programs related to school buses and transit vehicles. But most of the policy recommendations will apply to both LDVs and MHDVs.

Short-Term Recommendations with Good Agreement

There are 15 short-term recommendations with good agreement (Table 9).

Table 9. Short-Term Policy Recommendations with Good Agreement

Rec #	Policy Recommendation
1.01	Rate design for demand charge mitigation to be enabled by stationary battery storage coupled to EV charging
1.09	Allow customers with on-site solar and/or storage to utilize commercial EV rates
1.10	Improve Optional Residential and Commercial TOU rates designed to encourage EVs (e.g., whole house rate), fund outreach efforts on the rate, and set target to secure 60% level of participation
1.16	Expand the definition of eligible customer-generator under current NEM tariff option to include customers that own and/or operate EVs and/or EVSE with bi-directional capabilities
2.03	Establish "reverse EE" rebates (pay for performance?) for EVSE installations that build permanent midday load
2.13	Allow V1G (Smart Charging/Managed Charging) to be counted as storage for Storage Mandate
2.16	Encourage low-cost, multiple VGI communication control pathways and cloud aggregators and put to-be-determined VGI communication requirements on the cloud aggregators, not on the EVSE or EV
2.18	Incentivize multiple EVs using a single charging station in long-dwell AC charging locations to keep charging load spread across as many vehicles as possible
2.19	Create utility programs to site higher-level kW charging for commercial applications in the best locations to encourage high utilization using grid planning studies, routes, demographics & other tools
2.20	Consider funding opportunities and rate design reform for stationary batteries co-located with DCFC chargers
4.01	Establish a VGI Data Program to help gather, model, and analyze data related to VGI use-cases; prioritize the analysis of use-cases screened out by this Working Group due to data unavailability
4.03	Better understand the trend toward 10-19 kW home charging and explore long-term solutions to mitigate the impact (e.g. studies, pilots, task forces looking at incentives and disincentives)
7.06	Grant funding opportunities can be amended to provide "plus-up" funding for DER arrangements that optimize grid conditions
10.05	State agencies should recognize that stakeholder's specialized VGI staff resources are limited and avoid workshops and hearings on the same day, and hold no more than 2-3 VGI and TE events per month
11.04	Investigate ADA and other obstacles to charger installation at MUDs and some high-density C&I locations

Of these 15 short-term recommendations with good agreement, half had broad "convergence" among all policy survey respondents. Such convergence means that all respondents agreed with each other – that there was a high degree of consistency among the responses. The exceptions to this pattern were seven recommendations 2.03, 2.13, 2.18, 2.19, 4.01, 10.05, and 11.01, which had more pronounced divergence of responses. For some, a significant number of survey respondents disagreed with the recommendation, such as 8 respondents who disagreed with 2.03 on reverse energy efficiency rebates. Policy makers and any future working groups should examine the recommendations and comments to better understand the sources of the divergence.

Again, while there was good agreement for these recommendations, survey comments also pointed to considerations and questions that might need to be addressed, for example:

- Recent EV rate design changes have looked to reduce demand charges, which would reduce the potential benefit from stationary batteries for demand charge mitigation (1.01).
- Many details need to be worked out for 1.09 commercial rates for on-site solar.
- "Reverse EE" rebates (2.03) seems contrary to state mandates, may be better implemented as demand response or TOU, and may need better definition of relevance and market segments.
- Some comments questioned whether V1G can be considered "storage" (2.13).
- Need to clarify the eligibility of battery-backed DCFC for SGIP (2.20).
- Rules 15 and 16 should adequately address grid impacts of high-kW charging in residences, otherwise policy should accommodate and not stifle customer choice (4.03).
- ADA issues are unrelated to VGI and outside the scope of the Working Group (11.04).

Public Funds for VGI

Working Group participants noted that implementing policy recommendations in several of the policy categories will require public funds (i.e., budgetary funds, grants, or loans) and/or ratepayer funds (as approved in IOU rate cases). For recommendations in Category #2 "develop and fund government and LSE customer programs, incentives, and DER procurements," public funds and/or ratepayer funds are a primary source of funding, potentially along with private funds. These programs and procurements will typically be for commercially-mature or market-ready VGI solutions. Recommendations in Category #7, "fund and launch demonstrations and other activities to accelerate and validate commercialization," will likely also require public or ratepayer funds, and typically these funds are spent on solutions not yet commercialized or market-ready. Categories #4 and #9 may also require public and/or ratepayer funds, for data programs, studies, and analyses that can inform further decision-making and support market growth, and for market education and outreach.

Many participants believed that public funds should continue to support a wide range of VGI solutions and initiatives, including mature mass-market programs; innovative pilots and demonstrations; data programs, studies, and analyses; and education and outreach.

Short-Term Recommendations with Majority Neutral

There are 16 short-term recommendations with majority neutral (Table 10).

Table 10. Short-Term Policy Recommendations with Majority Neutral

Rec #	Policy Recommendation
1.06	The pricing signal received by the EV and that received by the EVSE should be aligned and consistent with one another and should incentivize and de-incentivize the same charging/discharging action
2.07	Create a strategic demand reduction performance incentive mechanism, include EVs as technology that can reduce and shift peak demand.
2.14	Prioritize, document and implement cost-effective use-case(s) for every transportation electrification plan, project, or program that is supported or subsidized by public funds, applied at commercial scale, and to be deployed within five years
3.01	Authorize new tariffs in CAISO ESDER Phase 4 that allow utilities to pay V1G aggregators to use managed charging to reduce the local distribution grid impacts of EV charging.
4.04	Perform detailed cost-effectiveness analysis for specific VGI use-cases in programs/measures that are ratepayer funded in order to quantify the impact on EV customers, ratepayers, utilities, and society
5.01	Bring automakers to the table to agree to allow limited discharge activity for resilience purposes to be kept under warranty if customers are willing to pay for upgraded bi-directional charging hardware.
6.03	Explicitly prioritize V2G use-cases for school buses with customer bill management to be included in the next cycle of PRP submissions by one or more LSEs, as well in the next phase of EPIC funding
7.01	Create pathways for TNC/rideshare drivers to reduce their costs by participating in utility programs and benefiting from make-ready infrastructure and charger rebates; by participating in state-funded programs like CALeVIP; and by securing direct access to utility rates when using public charging
10.02	Use the proposed Joint IOU VGI Valuation Framework (6 dimensions) and associated use-cases to reference, articulate, and communicate about VGI in policymaking across CA state agencies.
10.03	Public funding of VGI use-cases should prioritize initiatives, projects, and programs that involves formal collaboration between at least one LSE and at least one automaker or EV service provider.
10.06	Develop a Virtual Genset model and reference implementation pilot.
10.07	Avoid over-regulation of EVSE specifications
10.12	Establish a voluntary task force to convene on regular basis to discuss technological barriers, including potential recommendations related to interoperability, communication pathways, and protocols
10.13	Establish a voluntary task-force to convene on regular basis to discuss barriers related to retail market design, including potential recommendations
10.14	Establish a voluntary task-force to convene on regular basis to discuss barriers related to wholesale market design, including potential recommendations
10.15	Establish a voluntary task-force to convene on regular basis to discuss barriers impacting customer adoption and participation, including potential recommendation

Some examples of comments that point to the sources of such neutrality include:

- Many comments said the recommendation was not clear, more details are needed, it is not policy ready, and/or the problem addressed by the recommendation needs better definition: 1.06 on consistent price signals, 2.07 demand reduction performance incentives, 3.01 on CAISO ESDER tariffs, 6.03 on prioritizing use cases for PRP or EPIC, 7.01 on TNC/rideshare, 10.06 on a virtual genset model, and 10.07 on avoiding over-regulation of EVSE specifications
- Implementing cost effective use cases for every plan, project, or program (2.14) may not add value in every case, and requires coordination between many agencies
- Allowing limited discharge under warrantee (5.01) was seen as out of CPUC jurisdiction, the decision of individual automakers, and is not a clear-cut topic
- There were concerns about being too prescriptive for 10.02 on using the VGI Working Group use-case framework and 10.03 on prioritizing collaboration between LSEs and automakers

- Comments on 10.12, 10.13, 10.14, and 10.15 on volunteer task forces were mostly similar and supportive across all four recommendations, but many said this idea should be combined with other recommendations.

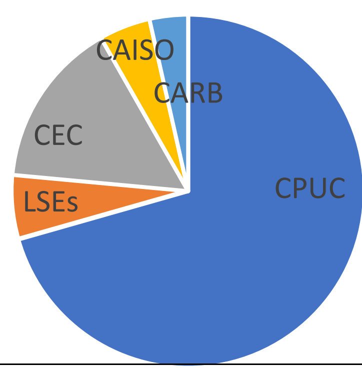
Of these 16 short-term recommendations with majority neutral, more than half had broad "convergence" among all policy survey respondents. Such convergence means that all respondents agreed with each other – that there was a high degree of consistency among the responses. The exceptions to this pattern were recommendations 1.06, 2.14, 3.01, 4.04, 5.01, 6.03, 7.01, which had more divergence of agreement than the others. Policymakers and any future working groups should examine the recommendations and comments to better understand the sources of the divergence.

Connecting the Dots: Lead and Supporting Agencies/Entities in Recommendations

Most of the 92 policy recommendations identify who the lead agencies/entities for implementing the recommendation would be, and some also identify agencies/entities in supporting roles.

- The CPUC is given as the lead agency in about two-thirds of the policy recommendations
- LSEs are given as the lead entities for five recommendations that all received strongest or good agreement: 1.15 on time-varying rates, 2.21 on performance-based incentives for building owners, 7.13 on quick approval of demonstrations, 9.03 on ME&O budgets, and 11.01 on demand charges for DCFC. Many other recommendations give LSEs supporting roles in carrying out programs and actions established or mandated by the CPUC or other organizations.
- The CEC is given as the lead agency for thirteen recommendations, relating to state-funded charging infrastructure, data and analysis, shared charging infrastructure, standards and requirements for buildings, EPIC funding, demonstrations and pilots, and public awareness and education programs. All but one (10.07 on over-regulation of specifications) received strongest or good agreement.
- CAISO is given as the lead entity for four recommendations: 3.01 on ESDER tariffs, 3.03 on real-time and ancillary markets, 3.04 on pathways for V2G participation in day-ahead and RA system services, and 3.05 on capacity-only system services. The last three are all medium-term recommendations with strongest or good agreement. CPUC is given as the supporting agency for three of the four recommendations, consistent with supporting the outcome where wholesale market rules are aligned with the highest-value opportunities for VGI.
- CARB is given as the lead agency for three recommendations: 2.24 on LCFS smarting charging, 7.02 on LCFS credits, and 11.02 on a shared benefit structure for LCFS.

Distribution of Lead agency/entity across all 92 recommendations



Short-Term Recommendations with Majority Disagreement

There are 7 short-term recommendations with majority disagreement (Table 11).

Table 11. Short-Term Policy Recommendations with Majority Disagreement

Rec #	Policy Recommendation
1.02	EV drivers across all sectors must be guaranteed direct access to their utilities' cost-competitive time-variant (e.g. TOU) rates; utilities must be allowed the option to own and/or operate at least a portion of the charging stations across all sectors so that their rates are directly available to EV drivers
1.05	Price signals received by EV customers should be relatively consistent (not necessarily identical) at a given time of day, across different sectors and price-setting entities; at the very least, different price-setting entities should agree on the time window where "off-peak" rates apply
4.02	Any Level 2 EVSE sold within the next two years should be capable of responding to external event or price signals, or user-defined criteria, and support OCPP, OpenADR, or IEEE 2030.5.
7.02	Improve the allocation of LCFS credits such that EVs with higher vehicle-miles earn higher credits, claiming credits is streamlined for EV drivers or their agents, and most credits are channeled back to driver/agent
10.10	A ML EVSE or charging station must be capable to provide energy services and may provide regulation services, and must support OCPP or an equivalent standard that supports an external energy management system for grid interactions
10.11	A HL Charging Station must provide energy services and must be capable of providing regulation services
11.02	Institute shared benefit structure for LCFS or similar funding between host site and EV driver/operator/owner

Some examples of comments that point to the sources of such disagreement include:

- Questions about whether utilities should own charging infrastructure and how that can be justified (1.02)
- Each LSE has its own cost recovery structure and there are limits to rate harmonization (1.05)
- Equipment requirements for EVSEs may seriously hinder the industry (4.02)
- It may be difficult for LCFS to cover EV drivers and may be difficult to administer (7.02)
- Concerns about relevance, technical standards, over-specification, and whether equipment and hardware specifications are in-scope for the Working Group, for both 10.10 and 10.11 on medium-level and high-level EVSE charging stations.
- Some said a shared benefit structure for LCFS is not really a VGI policy (11.02)

Of these recommendations, two had broad “convergence” among all policy survey respondents as to their common disagreement – 10.10 and 10.11. The other recommendations -- 1.02, 1.05, 4.02, 7.02, and 11.02 -- had high divergences of agreement and disagreement even as the majority disagreed with the recommendation. Policy makers and any future working groups should examine the recommendations and comments to better understand the sources of the divergence.

Connecting the Dots: Policy Recommendation Overlaps and Connections

Many of the 92 policy recommendations overlap with each or are connected to each other. Working Group participants, in policy survey comments (Annex 8) and in further discussions noted these overlaps and connections and recommended that related policies be considered together. Examples of these overlaps and connections include:

- Submetering is addressed by 1.04, 1.12, and 8.02
- Net metering (NEM) is addressed by 1.16 and 2.16
- Cost-effectiveness and cost-benefit analyses are addressed by both 4.01 and 4.04
- Stationary batteries co-located with EV charging is addressed by 1.01, 2.20, and 7.06
- Charging infrastructure funded by the CEC or by utilities and other LSEs is covered by 2.05 and 2.06
- Market participation of V2G resources is addressed by 3.04 on system services from V2G and 3.07 on participation options for V2G
- Backup power and resiliency (vehicle-to-building V2B and vehicle-to-microgrid V2M), including pilots and incentives, are addressed in different ways by 2.08, 5.02, and 5.03
- Extending SGIP to VGI is addressed by 2.12 and 7.04
- Incentives for charging infrastructure in new construction are addressed by 8.01, 9.01, and 11.05
- Four recommendations relate to opening up new value streams that can be captured by EV energy management systems (EV EMS), and also provide an additional type of "incentive" or benefit-enabler: 2.04 on BTM load balancing to avoid distribution system upgrades, 2.17 on customer load management to avoid or defer utility distribution upgrades, 2.22 on non-wires alternatives to similarly avoid or defer utility distribution upgrades, and 2.18 on multiple EVs sharing a single charging station

Policy Recommendations Related to Policy Action Already Underway

There are many policy actions and venues already underway related to VGI. The Working Group took note of a full array of policy actions already underway that related to its policy recommendations. In particular, there are 16 recommendations flagged as relating to "policy action already underway" by the CPUC Energy Division (Table 12).

However, even though action is already underway related to a policy recommendation, the Working Group recommends that all such policy recommendations still be considered in strengthening or extending any existing or planned policies, and that other proceedings that may be addressing these policies take note of these recommendations.

This is underscored by the fact that almost all of the 16 recommendations in Table 12 have strongest or good agreement. For example, two policies related to submetering, 1.12 and 8.02, have good agreement, indicating that the CPUC may wish to further consider sub-metering policy development. There is also strongest agreement for 1.13 on time-variant charging rates, 2.09 on pilots, 2.11 on dealer incentive programs, and 9.03 on ME&O budgets. Two recommendations, 2.24 on LCFS smart charging and 6.04 on NEM tariffs, received "majority neutral" classifications.

Many others of the 92 recommendations put forward by the Working Group may also relate to actions already underway and Table 12 is by no means comprehensive. The detailed information on policy recommendations (Annex 6) contains further notes on related proceedings and other venues. Table 12 only represents partial information collected from participants and comments by CPUC Energy Division staff. Further comments by Working Group participants on other actions already underway and the need to strengthen actions already underway are linked in Annex 1.

Table 12. Recommendations Related to Policy Action Already Underway

Recommendations	CPUC Energy Division Staff on Action Already Underway
Establish EV TOU rates that don't require separate metering or submetering (1.04) If dynamic rate is unavailable, increase the differential between standard and EV TOU off-peak charging rate (CPUC comment: already adopted) (1.08) Develop a standard implementation guide for utilities to provide real-time price and event (control) signals to EVSEs, Charging Station Management Systems (CSMSs) and EV drivers (1.11) Retail EV charging rates should reflect cost of generation, delivery, GHG, and other relevant value streams; all EV charging rates should be time-variant, starting with simple TOU rates and then enabling optional alternatives such as dynamic rates (1.13) Reduce or eliminate demand charges for DCFC, but scale up with utilization to create more demand-responsive rate (11.01)	Multiple rate cases are already considering these policies, or some policies are addressed through recently implemented rates or proposed commercial EV rates under review
Re-examine or use existing AMI alternative approaches to submetering in residences for EVs, DERs and demand responsive appliances to lower cost and level the playing field for DERs (1.12) Finalize submetering protocols/standards to increase accessibility to more favorable EV TOU rates (8.02)	These are already being addressed through ongoing submetering work in the DRIVE OIR
Require managed charging capability in utility customer programs, incentives, and DER procurements (2.05)	All IOU programs currently require load management participation for customers to be eligible
Require all government-funded charging infrastructure to have smart functionality (2.06) Leverage existing pilots to identify bottlenecks for increasing deployment and reducing costs. Encourage utilities and other LSEs, in partnership with private entities, to establish dedicated programs for school bus charging (2.09)	These are already a goal in the Draft TEF
Create an EV Dealership VGI upfront incentive program whereby utilities can reward dealers for installing or enabling VGI functionality at point of sale (2.11)	SDG&E and Plug-in America are already testing this in a pilot and results are pending and other similar testing of this concept will occur as more dealers sign up to participate in the LCFS upfront rebate program

Align LCFS smart charging framework with IOU TOU rates (2.24) **	Aligning the LCFS incremental incentives with IOU TOU periods is already a requirement in CARB's regulation. The smart charging pathway is currently based on the CPUC avoided cost calculator. **
Drastically simplify NEM tariffs and streamline NEM applications for EVs; and encourage better communication of EV TOU and NEM rates to the general public and businesses (6.04)	There is already a NEM 3.0 effort underway, and multiple efforts to streamline/simplify EV rates to ensure they can be combined with solar-plus-storage.
Incentives for Title 24 new construction – residential multi-unit dwellings and some commercial and industrial parking facilities (especially workplace and large destination) (8.01)	Consistent with a CPUC staff proposal; new construction incentives are addressed in Section 5 of the Draft TEF
Utilities develop coordinated ME&O budgets through transportation electrification plans, to inform EV customers of the lower cost of fueling EVs using dynamic rate options and other VGI opportunities (9.03)	Every IOU program budget already includes ME&O, and the draft TEF proposes a new aligned ME&O effort. The Draft TEF section 11.2 mentions TOU rate education, and this could be re-focused to provide direction and alignment. Non-IOU ME&O is also stated in draft TEF.
Prevent policies that make VGI a primary goal over the needs of drivers or CARB and AQMD mandates to support 2045 carbon neutrality and 2030 air quality requirements; don't add net cost to TE end users or hinder EV adoption or equity goals due to VGI and fund efforts to study and monitor this issue (10.01)	This is a goal for all CPUC programs approved for IOU ratepayer funding,

** Recommendation 2.24 on LCFS smart charging falls under the jurisdiction of CARB as the lead agency. The inclusion of this recommendation as related to policy action already underway is based upon CPUC Energy Division staff comments confirmed by CARB.

Digging Deeper: Policy Strategy Tags

Each of the 92 recommendations has one or more "policy strategy tags" that the Working Group assigned. This mapping of tags can show the collective contribution of policies to achieving distinct policy strategies and goals. Annex 7 shows which recommendations in which categories are associated with 16 different policy strategies and goals.

Medium- and Long-Term Policy Recommendations

There are 15 recommendations that address the medium-term (2023-2025) or long-term (2026-2030), given in Table 13. All of these are either strongest agreement (1.15, 1.18, 3.03, 5.03, 7.13) or good agreement, with just one classified as majority neutral (1.19 on performance-based ratemaking).

Table 13. Medium-Term and Long-Term Policy Recommendations

Rec #	Policy Recommendation
Medium-Term	
1.15	Prompt CPUC approval of time-varying EV rates applications
1.17	In addition to an EV export bill credit (under NEM or another framework), a supplemental credit should be considered for environmental component, e.g., based on SGIP GHG signal to determine marginal emissions rate
1.18	Establish voluntary "critical peak pricing" tariffs for non-residential charging that offer reduced TOU rates except during event-based flex alert or critical peak periods, while providing significantly increased on-peak prices
2.21	Provide a performance-based incentive to temporarily provide grid services, for building owners or EVSP providers who recruit a certain fraction of EV drivers to opt in, implemented as a long-term contract through procurement
2.22	Issue non-wires alternative competitive procurements (RFOs) targeted to EVs/EVSPs that can limit demand during peak times
3.03	Enable aggregations of EVs on managed charging to participate as resources in real-time energy markets and ancillary services market
3.04	Need clarity and conclusive decision on what pathway (PDR vs. NGR) will enable V2G resources to offer Day-Ahead Energy and RA System services, and clarity on PDR timeline and roadmap if PDR is the chosen pathway
3.05	Alternative PDR participation model or new capacity-only designation for resources to provide ancillary services only, to allow BTM charging to participate, single site or aggregated
3.07	Coordinated effort by state agencies and IOUs and other LSEs to establish market rules and participation options for separately metered V2G customers.
5.03	Develop standards and requirements for buildings which will support the use of the EV's main power batteries for customer resiliency
7.13	Create a mechanism which allows for quick approval of demonstrations for technology and for determining market interest
7.14	Pilots for shared charging infrastructure for commuter-based fleets, both public and private, including transit commuter buses and company fleets and shuttles.
Long-Term	
1.19	Institute performance-based ratemaking that includes both capital expenditure and operational expenditures, to encourage more efficient EV-related distribution build-out
1.20	Create tariffs specific to medium/heavy duty vehicles, fleets, and rideshare
6.11	Coordinate the development of interconnection and technical standards with the VGI Working Group effort

As the CPUC and other agencies and entities move forward with the short-term recommendations, and also begin to address the mandates of SB 676, these medium- and long-term recommendations will be relevant. The Working Group's suggested next steps in this report's Conclusion section address this further.

SECTION C. PUC QUESTION (C): HOW DOES THE VALUE OF VGI USE CASES COMPARE TO OTHER STORAGE OR DERs

The Working Group did not provide a direct answer to PUC Question (c), "how does the value of VGI use cases compare to other storage or DERs," but does offer guidance on how to complete this work going forward.[53]

Discussions revealed that this is a complex topic which can require a great deal of analytical resources and expertise. To answer the question quantitatively in the manner originally envisioned would require rigorous cost-benefit analysis. Due to time, data, and expertise constraints, the Working Group did not perform cost-benefit or cost-effectiveness analysis of either VGI use cases or other DER use cases. The Working Group also faced limitations in getting private-sector cost information and could only assess costs on a relative basis. And given that the Working Group was comprised entirely of volunteer participants, many of whom did not have direct expertise in storage and other DERs, there was insufficient time, volunteer availability, and expertise to consider the value of storage and other DER use cases.

Instead, the Working Group recommends that the PUC address this question through further efforts with the necessary expertise, for both VGI and other DERs. These further efforts can recognize and incorporate the wealth of work and perspectives on VGI use cases produced by the Working Group (see Annex 1 for the materials produced by the Working Group).

<u>Guidance on How to Compare VGI with Other DERs</u>

The Working Group suggests that further efforts consider three approaches to comparing VGI with storage and other DERs: quantitative cost-benefit comparisons, qualitative comparisons, and use-case-based comparisons.[54] Each of these approaches has its merits and difficulties, as noted in Table 14. The Working Group also identified some potential resources and references related to costs, benefits, and value comparisons that could be considered in further efforts, although these resources were not reviewed or assessed (see Annex 3).

Table 14: Recommended Approaches for Comparing VGI with other DERs

Approach	Merits	Difficulties
1. Quantitative cost-benefit comparisons	• Provides numerical comparisons of value • Can also incorporate the value of managed charging (including direct and indirect, V1G and V2G) vs. unmanaged charging • Satisfies direction from CPUC in DRIVE OIR; complies with CPUC D.19-05-019	• Cost data difficult to obtain or not available; may require demos or pilots to provide data • Potential disagreement over the methodologies and assumptions employed in conducting numerical comparisons • Defining VGI cost additionality relative to baselines

[53] The Working Group notes that VGI is considered as one form of DERs and is defined as a DER in Assembly Bill 327.
[54] See D.19-15-09, CPUC decision guiding cost-effectiveness evaluation of DERs. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M293/K833/293833387.PDF

2. Qualitative comparisons	• Can provide insight for policy making in supporting VGI and in having the value of VGI complement the value of other DERs • Can also give insights into the first and third approaches	• There are many possible scenarios to compare, and the results of one scenario cannot necessarily be compared to the results of another scenario • Does not comply with CPUC direction in DRIVE OIR that VGI be compared to other DERs; does not comply with CPUC direction on comparative analysis in D.19-05-019
3. Use-case-based comparisons	• Leverages the use-case work of the Working Group and potentially allows a simplified apples-to-apples comparison • Can provide insight for policy making in supporting policies associated with specific use cases • Can also be quantitative with similar merits and difficulties as the first approach	• Does not comply with CPUC direction on comparative analysis in D.19-05-019 • Lack of cost data to support comparisons; may require demos or pilots to provide data, or relative cost comparisons as was done by the Working Group for VGI use cases • There are many distinct VGI use cases and comparing on an individual basis can be time-consuming • Requires developing the equivalent DER use cases to match VGI use cases, which the Working Group has not done • What metrics would be measured? What does a positive or negative comparison look like?

1. Quantitative cost-benefit comparisons. A variety of potential studies are available that could address quantitative comparisons; see Annex 3. However, the Working Group did not assess or endorse any quantitative studies, given time and expertise limitations. It is not clear the extent to which existing studies provide cost-benefit comparisons of VGI with other DERs that would be relevant to California. Thus, even identifying and selecting such studies will be a significant effort. One next step would be to establish the criteria that should be used for selecting, assessing, and utilizing such studies, including the relevance to California.

Participants noted a number of methodological issues that would need to be considered and addressed in conducting quantitative cost-benefit comparisons. On the costs side, participants noted there is a scarcity of publicly-available cost information, underlined by the difficulties and time constraints that the Working Group faced in getting private-sector participants to share cost information during the process to score use cases on costs, benefits, and ease of implementation (see Section B). Given more time, additional data would potentially have been available. There is a continuing need to first develop better cost information, such as from large-scale demonstrations and competitive solicitations, and to further identify existing public sources of cost data. This may be a case when "an ounce of commercial activity would be worth a pound of research."

The definition of "costs" itself is not straightforward, considering the different costs (and prices) to different parties involved in a particular use case, such as equipment and vehicle providers, customers, electricity providers, and aggregators (for further discussion see Annex 1 links to materials on cost methodologies). Some participants also highlighted the need to better define the incremental or additional costs associated with VGI, as distinct from costs that would otherwise be incurred anyway in owning and operating EVs, such that true “apples-to-apples” comparisons of VGI costs and benefits can be made.[55]

On the benefits side, there is a need for a consistent set of assumptions for the benefits from the same service utilizing VGI compared to other DERs. The benefits of VGI can also come from complementary roles with other DERs, in which the value of the other DERs may also increase. Such complementary roles need further understanding when making comparisons between VGI and other DERs.

Further, there is considerable scope for determining the best metrics for reporting on cost-benefit comparisons of VGI with other DERs, including such metrics as gross bill savings, net customer savings, customer benefit/cost ratio, and other standardized cost-benefit metrics including those that address ratepayer impacts and societal costs. Some participants of the Working Group said some metrics should be prioritized over others.

2. Qualitative comparisons. A qualitative comparison of a VGI use case with another DER use case can highlight the uniqueness and potential benefits of VGI in both complementary and substitution roles relative to other DERs. Qualitative comparisons can be developed in terms of characteristics such as location, resource availability, market participation and pricing, application, size/scale, ownership, capital investment, lifetimes of equipment and contract periods, and environmental benefits. For example, a stationary battery for a residential or commercial building might be compared with an EV for personal use along these dimensions, with the following *possible illustrative* conclusions:[56]

- Location and resource availability: a stationary battery may have comparatively greater availability but only for a fixed location, while EVs may have more limited availability but offer many variable locations from which to provide grid services needed at a given time and location.
- Market participation: both EV and stationary battery are subject to retail pricing but there are differences in how they can participate in the wholesale market
- Size: an EV battery is typically larger than a residential stationary battery, while the opposite can be true compared to a stationary battery in a commercial building
- Scale: EV batteries must typically be aggregated to a larger scale for participation in wholesale markets and do not need to be separately metered, while commercial batteries may participate individually and must be separately metered.
- Capital investment: EVs don't have to be purchased or leased by distribution utilities and LSEs to obtain the benefits of storage for their distribution grids and load-serving needs, in contrast to utility-scale stationary storage owned by distribution utilities and LSEs.
- Lifetimes of equipment and contract durations: an EV will typically have a lifetime of 5-10 years and contract durations as short as one year, while a stationary battery will typically have a lifetime of 10-20 years and longer-term contractual periods.

3. Use-case-based comparisons. Some storage and other DER use cases could be characterized along some of the same six dimensions of the use case assessment framework that Working Group employed to assess VGI use cases. These dimensions include Sector, Application, Type, Approach, Resource Alignment, and Technology (see Section B). Participants noted in particular the potential overlap of the

[55] See D.19-15-09, CPUC decision guiding cost-effectiveness evaluation of DERs.
http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M293/K833/293833387.PDF

[56] Annex 1 gives a further resource by Sumitomo provided to the Working Group as an example of a qualitative comparison.

Sector, Application and Approach (direct vs. indirect) dimensions of VGI use cases with other DER use cases. If VGI and other DER use cases can be put into the same framework, then storage and other DER use cases could potentially be scored (by DER experts) in the same manner that the Working Group scored VGI use cases. The resulting scoring of both VGI use cases and other DER use cases could be compared on a similar basis, for benefits, costs, and ease of implementation. Such comparisons should:

- Configure the comparisons to compare "apples-to-apples" as much as possible
- Compare based on which DERs provide which grid services (i.e., for the same application)
- Compare by sector—home, fleet, workplace, public, large MUD, etc.; and for different viewpoints—customer, ratepayer, utility, CCA, etc.
- Identify which VGI use-cases have higher vs. lower potential benefits for utilities & ratepayers, how low technology costs would have to be to enable those use-cases, and how much value would arise from spending a similar amount of customer/ratepayer dollars for other DERs that can provide the same services.
- Map out dimensions of sector-based "complex" or "multi-use application" use cases (i.e. one sector, many applications) from the perspective of existing utility and other LSE DER programs – such as NEM, SGIP, EE, CPP/BIP. See which use cases from the VGI Working Group map to which use cases supported by these other DER incentive programs.

Such comparisons between VGI use cases and other DER use cases providing the same or similar services can illuminate trade-offs between the two options for a decision-maker, as well as provide a bottom-up understanding to complement top-down market-based comparisons.

Some Other Viewpoints

Some Working Group participants disagreed with the emphasis on quantitative comparisons and cost-effectiveness for VGI implied by PUC Question (c). Rather, they favored a focus on PUC Question (b) and continuing to focus on policies for "leveling the playing field" for VGI, and understanding and prioritizing the highest-value activities and policies for EV adoption and managed charging for both near-term and long-term.

Some Working Group participants also emphasized pursuing further comparative analyses of scenarios with managed charging via VGI, compared to scenarios with continued unmanaged charging. In their view, the most informative and relevant comparisons are to be made between scenarios with VGI (containing direct managed charging and/or adoption of time-varying rates) and counterfactual scenarios of unmanaged charging without VGI. Here again, VGI value can be discovered or determined based on analytical cost-effectiveness assessments or market-derived cost-competitiveness information.

CONCLUSION AND NEXT STEPS

The VGI Working Group is proud to present this report and associated materials. Working Group participants were motivated by a conviction that VGI affords many potential benefits. Many opportunities to realize these benefits are available today and will grow rapidly as EV adoption expands, as shown by the extensive work completed by the Working Group on use case assessment and policy recommendations. This work provides a solid foundation for the next stages of VGI in California.

The high degree of cooperation and collaboration achieved–among over 85 organizations and individuals participating voluntarily during the ten-month course of the Working Group—also demonstrates that VGI is a unique and effective convening umbrella or venue for fostering collaboration between the electric power and EV/charging sectors, and among many types of industry, government, advocacy, research, and utility and CCA stakeholders.

The next steps beyond this report for California state agencies, the California ISO, utilities, community choice aggregators and other load-serving entities, and other VGI stakeholders could include:

Policy actions

- Continue inter-agency efforts to advance VGI understanding, piloting, and large-scale deployment, leveraging private and public funds for that effort. Efforts should be inclusive and cover a wide variety of VGI solutions at different levels of maturity and readiness.
- Prioritize actions and resources to ensure robust and streamlined implementation of the 92 policy recommendations produced by the Working Group, taking into account the 1200-plus detailed comments generated by the Working Group on these recommendations.
- Use the policy recommendations and other materials from this report to inform and motivate state agency action on several ongoing VGI issues, including V2G interconnection, submetering, VGI customer programs, and EV rate design.
- Map the use cases put forth by the Working Group onto existing and planned California policies and programs for transportation electrification, and identify gaps in policies and programs for addressing priority use cases.
- Further explore and understand the implications and relevance of this report for the development of the Transportation Electrification Framework (TEF).
- Use the policy recommendations and other materials from this report to inform development of the strategies and quantifiable metrics called for by SB 676.

Interagency coordination and convening

- Convene a further working group or other venue composed of both VGI and DER experts and industry representatives, to conduct comparisons of VGI use cases with other DER use cases, perhaps starting with "net value" analysis on the use cases put forward by the Working Group.
- Coordinate and fund an inter-agency effort to conduct the demonstrations and pilots recommended by the Working Group based on collaborative and coordinated actions across agencies.

Further analysis

- Assess customer interest, acceptance, and retention, and what is required (and associated costs) to get customers to participate in VGI programs (e.g., incentives, marketing, dealership education).
- Identify and obtain publicly available data on VGI costs, as well as baseline data on driving and charging patterns relevant to different use cases.
- Conduct cost-effectiveness tests and cost-benefit analyses as part of further answers and understanding of PUC Question (a) on use case value and PUC Question (c) on comparisons with other DERs, and as part of assessing impacts of pilots, programs, and policy recommendations.
- Building on the single-application use cases defined in Section A, further define and explore "complex" or "multi-use application" (multiple application) use cases that can "stack" or combine the values of multiple services and benefits for single use case.
- Undertake a focused and detailed review of the results from the use-case value scoring exercise, to identify next steps for understanding VGI net benefits, with emphasis on use cases that were not scored but could provide value in the medium- and long-term.

California can become a global leader in transportation electrification and VGI implementation, but only with concerted and committed efforts to improve regulatory policies and expand market opportunities. The Working Group showed that there are many potential VGI use cases that can provide value, and that the potential market for VGI solutions is diverse and interwoven across a broad swath of the transportation and power sectors. Given the use case assessment work performed by the Working Group, it appears that the work of developing markets for VGI solutions will demand persistent action for the next several years. California should take an inclusive and collaborative approach to VGI opportunities given the evolving nature of the regulatory and market landscape.

The Working Group, consisting of organizations voluntarily contributing their limited time and resources, commends this report to the leaders of the California ISO, CEC, CARB, and CPUC. We ask for thoughtful consideration of these recommendations and a timely response to this plea.

GLOSSARY

Aggregator – an entity that aggregates, coordinates, and controls multiple DERs to provide energy services as an aggregate of the individual DER capacities and capabilities.

Ancillary Services – energy services that do not directly feed load, but keep a power system functional; e.g. – voltage and frequency regulation, reactive power injection.

Behind the Meter (BTM) Storage – energy storage systems that operate "behind the meter," i.e not on the transmission or distribution system, but onsite with an electricity customer.

Curtailment – the intentional reduction of output of a renewable energy system below what it could have otherwise produced.

Demand Charge – a charge for the maximum capacity that a customer uses during a billing period.

Demand Response – a strategy wherein loads are taken offline or curtailed in order to lower system demand. A variety of controls are possible, from passive time-varying rates to direct and active commands from the load-serving entity or from an aggregator.

Distributed Energy Resource – energy resources - including small scale power generation, energy storage, energy efficiency, energy demand response, and electric vehicles – that operate onsite at a customer's premises or business, or on the distribution level of the power system.

Distribution Upgrade Deferral – any investment that allows for the delay or nullification of planned system upgrade investments, such as local DERs or customer energy management systems.

Electric Vehicle Service Equipment – any equipment that is used directly to charge electric vehicles, or is used to connect vehicle chargers to the power grid or other energy resources.

Electric Vehicles – Vehicles that solely employ electric motors and batteries, or hybrid plug-in vehicles that combine electric motors and batteries with internal combustion engines that can be charged from an external power source. Also called plug-in electric vehicles (PEVs).

Electricity Service Providers – any load-serving entity (LSE) that offers electric service to customers within a given service territory

Grid Interconnection – the point of connection between a DER and the distribution grid.

Inverter – a device that converts DC (battery) power to AC (grid) power and vice-versa.

IOUs – Investor Owned Utilities are Load Serving Entities (LSEs) that fall under the regulatory jurisdiction of the CPUC, as compared to other LSEs such as community choice aggregators (CCAs) and municipal-owned utilities (MOUs) that do not.

Load Serving Entities – entities that have been granted authority pursuant to state or local law or regulation to purchase wholesale electricity and directly serve electricity to retail customers; investor-owned and municipal utilities, as well as electric co-ops and community choice aggregators are load serving entities in California.

Managed Charging – coordinated shift/modulation of time or level of EV charging or discharging in response to a variety of possible signals, both passively (indirect use cases) and actively (direct use cases); examples of signals are time-varying prices and signals of grid conditions; includes unidirectional V1G and bidirectional V2G and V2B/V2H as well as indirect and direct control approaches.

Microgrid – an integrated localized grid system that can operate independently from connection to the larger grid. Microgrids can vary in size from single-home scale to a variety of community scales.

Peak Period - the period in a given time frame at which the power system is experiencing its peak demand.

Peak Demand – the greatest level of energy needed within a given time period.

Point of Common Coupling – the point where the generating facility's local electric power system connects to the electrical company's electric system, such as the electric power revenue meter or at the location of the equipment designated to interrupt, separate or disconnect connection to the grid

Resiliency – the ability of the grid to operate during potential disruptions; and also the ability to provide local or customer-level solutions if the grid undergoes an accidental or intentional outage and is not available.

Resource Adequacy – a set of regulatory and planning constructs used to ensure that there will be sufficient generating resources available to serve electric demand under all but the most extreme conditions

Submetering – the measurement of electricity consumed by a specific load, such as an EV, separate from or as part of a customer's overall metered account.

Time-Varying Rates – an energy tariff wherein the price of energy varies depending on the time of day; can be static time-of-use (TOU) rates fixed for specific times of the day, or dynamically varying.

Uni-Directional / Bi-Directional Grid Interactions – EV use cases are defined by the flow of energy between the EV and the source powering it. Uni-directional grid interactions are situations in which power flows from the grid to the EV. Bi-directional grid interactions specify situations in which power can flow from the grid to the vehicle and vice-versa.

Use Case – use cases represent the different ways in which EV charging can be integrated with the grid (or home/local power system) to provide value. Use cases help articulate how value streams can flow to different stakeholders, including EV owners and fleet managers, workplaces and other charging site hosts, charging service providers, utilities and CCAs, ratepayers, and grid operators.

Value Stacking – obtaining multiple value streams and services, for example both customer bill management and system day-ahead energy, from a given VGI use case.